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ABSTRACT

This packet contains four units of informational materials and transparency masters, with accompanying scripts, for teachers to use in a soil science course in vocational agriculture. Designed especially for use in Texas, the first unit discusses the importance of soils. In the second unit, the nature and properties of soils are discussed, organized in these four topics: soil components, soil properties, soil classification, and soil sampling. The third unit covers soil conservation, while the final unit outlines measures for conserving and controlling soil water. Each topic section of the units contains information sheets, scripts for transparencies, references, and transparency masters. A glossary of terms completes the packet. (KC)

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SOIL SCIENCE

III-A-1 to III-D-4

BASIC V.A. I

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SOIL SCIENCE

Unit A: Importance of Soils

Topic 1: Influence of Soils and Soil Formation

*All terms underlined are included in the "Glossary of Terms."

I. How do Soils Influence Our Nation?

Much of our nation's greatness is due to the productive capacity of its soils. Our soils contribute to the production of happiness, progress, and prosperity that all Americans are able to enjoy. The nation's soils have been the foundation of our independence, safety, and welfare.

The production of food is dependent upon the ability of our soils to sustain plant life. Without it, people could not exist. America is one of the few nations in the world today that produces enough food to sustain its population. The soils contribute the food in wartime that enables us to maintain troops in other lands. In peace time, food is sent to millions of hungry people in other parts of the world.

Understanding our soils will enable us to continue producing food for our nation.

II. Influence of Soils in Texas

Soils are a vital natural resource for the production of food, forage, trees, and fiber; and for development related to industry, recreation, housing, transportation, and water resources. Land use planning in Texas requires many value judgments about individual soils and relationships among soils. Planners must consider soils as part of the total environment basic to the needs of a growing population. The population of Texas was about 11.2 million in 1970. Some 80 percent of these people were classified as urban. It is projected that by the year 2000, the population will increase as much as 75 percent over the 1970 figure, and even a greater percentage of the population will likely live in and near urban complexes. This expanding urban population will, however, continue to be strongly integrated with agriculture and other land-related natural resources of the state.

Transparency No. 1

Texas has a total surface area of 171.5 million acres of which about 168.7 million acres is land and 2.8 million acres is covered with water.

Of this total land area, Texas is endowed with about 36 million acres that are well suited for crop production. More than 8 million acres of this cropland is irrigated. Approximately 23 million acres, mostly in East Texas, are classified as forest land. About 12 million acres of this forest land produce commercial lumber, veneer, poles,

piling, fiberboard, paper, and other pulp products. Nearly two-thirds of Texas or about 100 million acres are used primarily for grazing. Approximately 85 percent of these acres are classified as rangelands which have volunteer pasturage, while the other 14 percent of the acreage is vegetated primarily with introduced grasses and is considered as pastureland.

Water use requirements for municipal, domestic, industrial, agricultural, and recreational purposes become greater each year with increasing population and associated developments. To help meet these demands, water reservoirs now cover about 1.3 million acres of the total 2.8 million land acres covered by water.

In addition to the land uses already mentioned, there are 3.2 million acres of land and water used for outdoor recreation in Texas, which are subject to administrative control by state and federal agencies.

III. Are Soils Permanent?

Soil only appears to be changeless and permanent. Actually, something is constantly being added or taken away from the soil. These changes tend to balance each other; therefore, soils appear to be stable.

The formation of soils is a long and slow process. It usually takes nature hundreds of years to develop one inch of topsoil. This much could be easily lost in one heavy rain. The Mississippi River alone deposits 730,000,000 tons of soil into the Gulf of Mexico each year.

This is only a small part of the total amount lost each year. If America is to maintain her productive soils that play such an important part in her well being, her people must have an understanding of what makes soils productive and practices that will keep them that way.

IV. What Factors Affect Soil Formation?

Soils form at the earth's surface as the atmosphere, sunlight, water, and living things meet and interact with the mineral world. At this junction, plants attach themselves to the soil, grow, photosynthesize their food, and give off oxygen. Plants and animals, large to microscopic in size, live on and in the soil utilizing carbon dioxide, oxygen, water, mineral matter, other plants and animals, and their decomposition products. All land based life and its continuation is thus made possible. Man is a part of this system; his life depends on it too.

Soils vary in their temperature and in the amounts of organic matter, air, and water they contain. The kind of soils formed at a specific site is determined by the interacting effects of (1) climate, (2) organisms (plants and animals), (3) parent soil material, (4) topography, and (5) weathering, each of which is imposed under local conditions. These five interactants are called "the soil forming factors."

As would be expected, these factors are interrelated—that is, each one affects others and is affected by others. Consequently, all have been responsible, at least in part, for the characteristics of our present-day soils. In short, the different soils are formed by different combinations of these factors. How they influence soil formation is discussed in the following paragraphs.

A. Climate

Temperature and rainfall greatly affect the rate of weathering. When temperature rises, the rate of chemical reactions increases and growth of fungi, soil bacteria, and plants increases.

For example, in the far North the rate of decomposition of organic matter is so slow that some of it never decomposes. In other words, it remains in a partially decomposed state and is known as "peat."

The rate and amount of rainfall in a locality greatly affect the soil. In areas of high rainfall, the soils are usually—but not always—leached and acid. When rain or snow falls during cold weather, they have less effect on the soil than rainfall during warm or hot weather.

Warmer conditions stimulate biological and chemical actions in the soil. Also, the rapidity or intensity of the rainfall greatly influences the soil by erosion and/or overflowing.

Slope and location of a field also affect erosion and drainage. Moreover, "free" water in the soil, not only tends to produce "layering" but also affects the growth of fungi and bacteria.

Too much water prevents or retards bacterial growth. Water and temperature also have the effect of swelling and contracting soil particles.

From the preceding, it is apparent that rainfall and temperature have both direct and indirect effects on soil formation.

The Texas climate varies from humid (wet) to arid (dry) and from temperate (mild) to subtropical. Various regions of the State are subject to sudden changes in the weather and to occasional events such as hail, torrential rains with flooding, tornadoes, freezes, hurricanes, and drouths. Sunshine is also abundant, ranging across the State from east to west. Relative humidity (east to west) at 6:00 p.m. commonly ranges from about 70 percent to less than 30 percent.

Temperature and humidity affect evaporation. Much of Texas has warm temperature and low relative humidity a large part of the year. Drouths are common in nearly every part of Texas, especially in the summer.

Soils, native vegetation, and land use reflect climatic variation in Texas.

B. Native Vegetation and Organisms

Vegetation and various organisms such as insects, "insect-type" creatures, animals, and man exert considerable influence upon the formation of a soil.

Certain types of soil bacteria and fungi aid in soil formation by causing decay or breakdown of the plant and animal residues in the soil. From these processes, carbon dioxide and other compounds essential to soil formation are released. Without soil organisms, organic materials would not decay.

Numerous insects, "insect-like" creatures, and animals contribute to the formation of soil by mixing the various soil materials. For example, earth worms absorb and digest certain soil substances which aid in decomposition. All such dead organisms add to soil organic matter.

Man and his civilized mode of living influences soil formation. For example, cultivation changes the surface layer, which influences soil-forming processes. The clearing of land removes native plant life, and thus destroys its natural effects on soil formation.

C. Weathering

Weathering processes are involved in soil formation in accordance with time or age, along with other soil-forming processes. The two major processes that are involved in the weathering of soils are: chemical and physical.

Chemical weathering is the result of the chemical reactions of water, oxygen, carbon dioxide, and other substances which act upon the soil materials (rocks, minerals, organic matter, etc.).

Physical weathering refers to mechanical forces caused by temperature changes such as heating and cooling, freezing, and thawing. As these chemical and physical processes occur, rock, minerals, organic matter, and other soil-forming materials are broken into smaller and smaller particles until, finally, soil is made.

Soils at different stages of weathering will differ widely; for weathering causes soils to develop, mature, and age much as people do. Soils, like people, develop rapidly during their youth.

Plant nutrients are quickly released from the minerals, plant growth increases, and organic matter accumulates. Soils then age more slowly as they continue to weather.

Eventually nutrients in the soil are depleted. Water moving through the soil leaches away many soluble portions. At this stage many soils are acid because the limestone in them originally is gone. As this supply of nutrients in the soil decreases, the amount of plant growth is reduced to the point that the organic matter decomposes faster than it is produced.

In permeable soils the fine clay particles tend to move downward from the surface soil into the subsoil during the weathering process. This movement, together with further breakdown of the rock material, accounts for the fact that many soil types have a higher percentage of clay in the subsoil than in the surface soil.

As soils go through the more advanced stages of weathering, they slowly decline to lower and lower levels of production. These soil changes, of course, take place over long periods of time—thousands or even tens of thousands of years.

D. Parent Material

Parent soil material is the unconsolidated mass of material from which a soil develops. Parent materials comprise the "C" layer of the soil profile which is located over earth bedrock. These materials are rocks, other minerals, and sometimes peat.

Parent materials are deposited in several different ways—some are residual; others are transported. The latter includes materials that are transported, or moved, by water; marine deposits that are transported by seas; alluvial deposits that are transported by streams, and lacustrine deposits that are laid down by lakes. Other deposited parent materials are transported by wind (loess deposits), gravity (colluvial deposits), and ice (glacial deposits).

The kind of parent material from which a soil is formed influences the many characteristics of that soil. Two important soil properties associated with parent materials are natural fertility and texture.

For example, shale and slate materials produce soils that are high in clay content; sandstone gives rise to soils that are sandy; limestone produces soils that are somewhat shallow; basalts and diorities produce deep soils that are rich in bases—alkaline; and so on.

E. Topography

Slope and drainage affect soil formation both directly and indirectly. On a steep slope, for example, the effect is direct, i.e., loose material is moved downward by runoff water and gravity.

This movement not only breaks up soil materials and adds them to the lower levels, but it exposes subsoil materials along the upper slopes. Also, the movement of soil materials has a pulverizing effect on the material being moved as well as on that left behind.

Slope affects the distribution of water that falls on the earth's surface. For example, runoff on steeper slopes reduces the amount of "percolation" of water (downward and upward movement) through the soil.

This is an important factor in the formation of soil profiles, since small particles in solution move down with the water. Slope and drainage are closely related. Soils that develop on level land tend to be poorly drained. The most productive soils are usually on level to gently-rolling slopes.

Drainage (or lack of it) affects the water table in a particular field or area. The water table, in turn, has a direct bearing on soil formation, especially where it is near the surface.

When a soil is saturated with water, little or no air can penetrate it, and the lack of air reduces the action of fungi, bacteria, and other soil-forming reactions in the soil.

A "wet" soil is, therefore, a "slow-forming" soil and is usually low in productivity. Because of this lack of air, undecomposed organic matter will accumulate in a wet soil. Poor drainage, accompanied by free water in the soil, thus reduces or retards plant growth and, therefore, affects soil formation.

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LAND USE IN TEXAS

cropland 35.6

forest 22.6

range 85.6

pasture 14.0

recreation & other 3.2

non-inventoried 7.7

total land area 168.7

land surface area covered by water 2.8

total surface area 171.5

MILLION ACRES

SOIL SCIENCE

Unit B: Nature and Properties of Soils

Topic 1: Soil Components

*All terms underlined are included in the "Glossary of Terms."

I. Soil Origin

It is the custom of agronomists to refer to the origin of the parent material of soils (a factor influencing soil formation) when referring to the nature of the soil. It is desirable to have an understanding of the origin and classification of parent material before considering the origin and classification of soils.

Soil parent materials may be referred to as a geological formation. It is a layer of material varying from a few feet in thickness to many feet. Wherever a geological formation is exposed at the earth's surface, either there is soil formation taking place or a soil has already developed from the exposed material. Productive soils develop only from minerals and rocks which are plentifully supplied with all essential elements needed to support plant life.

Transparency No. 1

Parent materials from which soils are formed may be classified as residual, transported, or cumulose.

A. Residual Materials

Residual materials are those which have developed from the underlying rocks and minerals. Most rock formations at the earth's surface are sedimentary. Other rock formations are classified as igneous or metamorphic.

Examples of residual materials are those which have weathered from limestone, sandstones, shales and slates, and many crystalline rocks such as granites and basalts.

B. Transported Materials

1. Materials that have been transported by water are classified as alluvial, lacustrine, or marine.
   a. Alluvial materials are sediments which have been transported by flowing water, such as small streams or large rivers.
   b. Lacustrine materials are those which have eroded into lakes from surrounding uplands. These materials were deposited in fresh-water lakes during glacial times. The greatest lacustrine deposits in the United States are bordering the Great Lakes.

c. Marine materials are those which were formed as sediments and were washed out to sea by rivers and later lifted above sea level. The principal marine sediments occur along the Gulf Coast and the Atlantic Coast.

2. Materials transported by wind are classified as either eolian deposits or loess deposits.
   a. Eolian deposits are sand dunes or deposits from present day dust storms.
   b. Loess deposits are soil materials that were deposited following the last glacial period. Loessial soil materials are silt-loam in texture and are found mostly in the Mississippi Valley.
3. Materials transported by ice are commonly classified into three topography types namely, moraines, till plains, and outwash plains. Ice deposits, according to geologists, were formed four times during our geologic history. The climate became so cold that a huge sheet of ice, one mile thick in places, moved south from Canada and covered the United States. As the ice moved southward, it ground the rocks beneath, gouged the valleys, scoured the loose materials off the hills, and mixed them together. This mixture, called glacial till, contained fine particles, stones, and sometimes huge boulders. This process of soil formation took place over a period of hundreds of years. Unlike residual soils, the glacial till does not contain the underlying rocks.
4. Materials transported by gravity exist to some extent at the base of all slopes. The soil materials that moved to the base of the slope in response to gravity is called colluvial material. It is more noticeable in mountainous topography where rock slides, slips, and avalanches are common.

C. Cumulose Material (Organic)—peat and muck

Cumulose materials are the plant residues that have been developed in shallow lakes and are recognized as peat and muck. Peat is the term used for material when the plants are recognizable. Muck describes the material when plants have decayed beyond recognition.

Parent materials of soil are constantly being developed today as rocks and minerals are weathered by both physical and chemical processes. Physical weathering processes include constant temperature changes, climatic conditions, rainfall, erosion, the action of animals, plants, and man. Chemical processes include such factors as oxidation, reduction, solution, hydrolysis, hydration, and carbonation.

II. The General Components of Soils

A. It should be emphasized at this point that soils develop from parent material by processes of soil formation that differ from processes of rock weathering, which produce parent material. As a soil is developed from the parent material certain

changes take place which distinguish the various soil layers and soil components. These changes are brought about largely by the shifting of materials or components either mechanically or in solution within the various soil layers.

Transparency No. 2

B. Soils are made of living and non-living materials which are of three forms; solids, liquids, and gases. The organic matter and minerals in the soil are the solid materials; and air and water, which move through the soil pores, are the gases and liquids. Approximately 45 to 49% of the soil (by volume) is mineral, 1 to 5 percent is organic matter, and 50% is water and air.

1. The mineral in the soil is inorganic and contains approximately sixty-four elements, which should be available to the growing plants. Some of the elements are of minor importance, but fourteen are considered to be of prime importance. Some of the important elements are nitrogen, phosphorus, potassium, carbon, oxygen, sulfur, calcium, iron, and chlorine. The mineral elements in the soil, with the exception of those introduced by man, come from rocks and decayed plants and animals.
2. Organic matter, another of the earth's solids, is formed from decomposed plants and animals such as plant roots, crop residue, green manure crops, and stable manure. Soils high in organic matter also are high in soil microorganisms, which affect the rate of decomposition of plants. Microorganisms obtain their energy, as do animals, by oxidizing organic matter. The amount of organic matter, often called humus, in the soil to some extent depends on climate and drainage; the soils in warmer climates usually have less organic matter.

The physical features, called tilth, of the soil are affected by the amount of organic matter in the soil. A high organic matter content in the soil will give the following benefits:

a. Makes the soil porous
b. Supplies nitrogen to the growing plant
c. It helps hold water in the soil so that growing plants are protected against droughts.
d. It aids in managing the soil moisture content.
e. Furnishes food for soil organisms
f. Serves as a store house for mineral nutrients
g. Minimizes leaching
h. Serves as a source of nitrogen and growth promoting substances
i. Stabilizes the soil structure

Soil water and air, the liquids and gases in the soil, are necessary for plant growth. The soil absorbs a great amount of water during rains, and water that is not absorbed by the soil drains away unless measures are taken to conserve it. The amount of moisture and air in the soil varies depending on climatic conditions. As the soil absorbs more water, there is less air in the soil; and as the soil dries out, air replaces the moisture. Plants receiving excessive water for too long a period of time will die because of a lack of oxygen. Soil in good physical condition will hold more water and air than poorer conditioned soils.

III. The Size of Soil Particles

A. A mechanical analysis is used to determine the percentages of different size groups of soil particles. These groups of soil particles (or soil separates) are determined by diameter ranges and are classed from coarse to fine.

Transparency No. 3

B. The size of soil particles is important because it affects the water holding capacity and workability of the soil. Gravel, sand, silt, and clay are the four mineral particles found in the soil.

1. Gravel and sand, the larger particles, can be seen with the eye; soils with a high percent of gravel and sand are infertile because they do not provide nutrients to the growing plants. These soils dry out quickly and are drouthy.
2. Silt particles are between those of sand and clay in size, and until they have weathered to fine-sized particles, they provide few nutrients for the growing plant. After rains, soils with a high percent of silt tend to run together and form a soil crust, and they erode very easily.
3. Clay, the smallest of the soil particles, holds soil nutrients, determines the acidity of the soil, and holds more moisture than either sand or silt. Clay particles are microscopic in size; their expansion and contraction depend on the amount of moisture present. In the presence of water, clay particles are separated by a film of moisture; as the moisture evaporates and the soil becomes dry, the soil contracts and leaves a crack in the ground. Clay soils dry out slowly and become cloddy unless properly managed. A good mixture of soil should contain sand, silt, and clay.

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classification of PARENT materials

A. RESIDUAL MATERIALS

1. Sedimentary -limestone, sandstone, shale
2. Igneous- granite, basalt, andesite
3. Metamorphic- marble, quartzite, gneiss

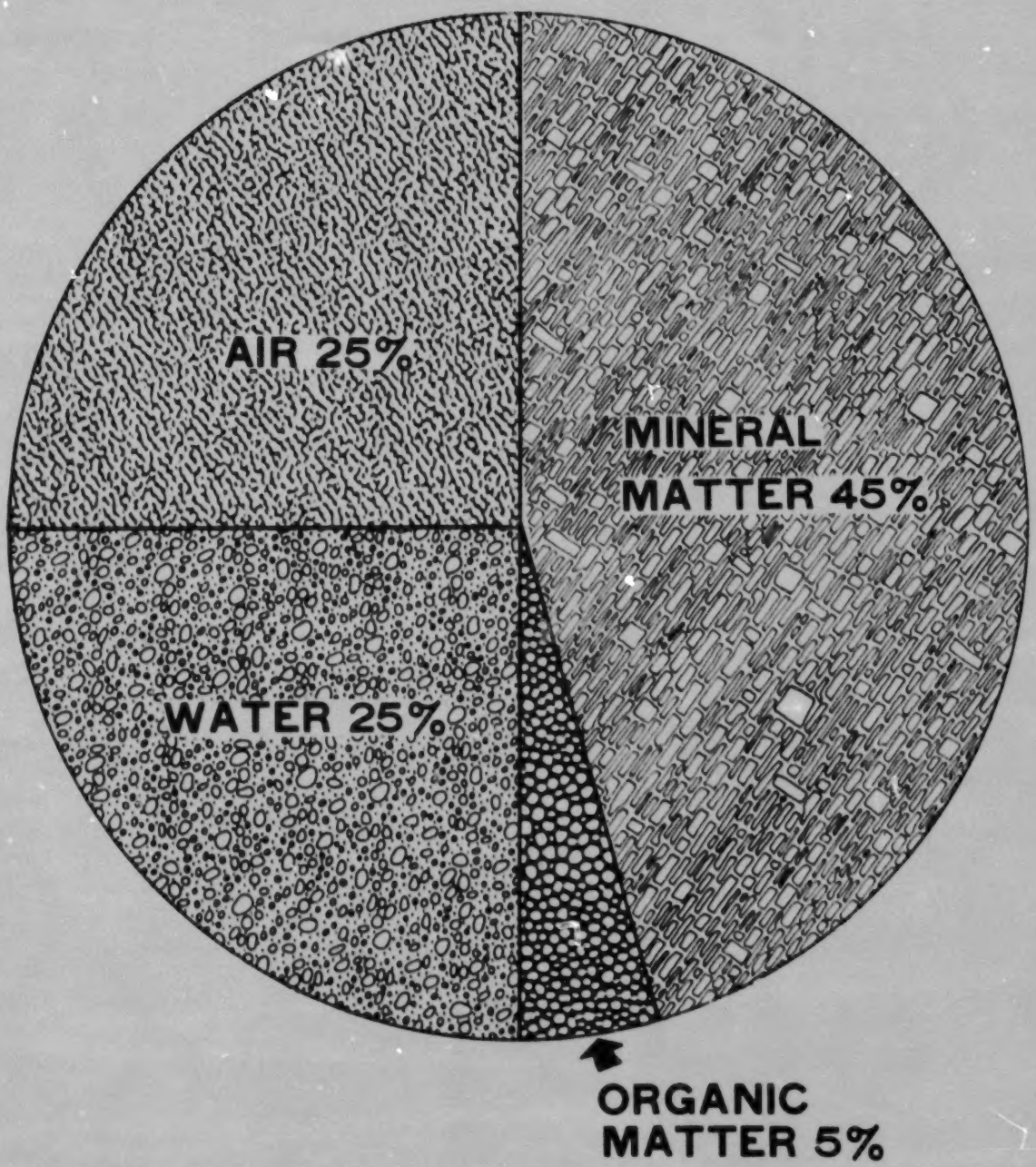
B. TRANSPORTED MATERIALS

1. Water
   - A. Alluvial -flowing water
   - B. Lacustrine -lakes
   - C. Marine- ocean
2. Wind
   - A. Eolian- sand dunes
   - B. Loess-silt loam deposits (Miss. Valley)
3. Ice
   - A. Moraines
   - B. Till Plains
   - C. Outwash plains
4. Gravity- colluvial

C. CUMULOSE MATERIALS

1. Peat- recognizable plant material deposits
2. Muck- plant decay deposits beyond recognition

COMPOSITION of AVERAGE SOIL



THE RELATIVE SIZES OF SAND, SILT, AND CLAY PARTICLES

SIZE OF SOIL PARTICLES

NAME	SIZE, DIAMETER IN MILLIMETERS
FINE GRAVEL	2 - 1
COARSE SAND	1.00 - 0.50
MEDIUM SAND	0.50 - 0.25
FINE SAND	0.25 - 0.10
VERY FINE SAND	0.10 - 0.05
SILT	0.05 - 0.002
CLAY	LESS THAN 0.002

SOIL SCIENCE

Unit B: Nature and Properties of Soils

Topic 2: Soil Properties

*All terms underlined are included in the "Glossary of Terms."

I. Major Factors Used to Describe Soil Differences

Although soils in general are made up of the same components, they differ in their properties or characteristics; and these differences affect or determine the way in which they should be managed. Soils differ in their color, texture, structure, consistence, and fertility and productivity. Even though many years of proper soil management are required to change the characteristics of the soil, farmers can make considerable improvements in the structure, fertility, and productivity of the soil.

A. Soil Color

Color is one of the most easily recognized soil characteristics and is very apparent in a soil profile. The surface colors of soil are classified as dark, moderately dark, light or very light; and the subsoil colors are classified as dull, mottled, or bright. The surface soil has a much darker color than subsoils because it usually contains more organic matter.

The color of the soil is usually a good indication of the amount of organic matter, the amount of moisture, and the texture of the soil. The dark color of topsoil usually indicates presence of organic matter. Light-colored soils are generally low in organic matter content, or high in sand particles, or contain iron or manganese oxide.

Soil drainage, which is the movement of water through and off the soil, affects the color of the soil and will determine the kinds of crops that can be planted. The color of a well-drained soil is red or brown; fair-drained soils are yellow, and poorly-drained soils are gray. A mottled subsoil indicates that the soil is saturated with water at certain times of the year and dry at other times.

B. Soil Texture

Soil texture refers to the size of the individual soil particles, and is thought of as the fineness or coarseness of soil particles, determined by the percent of sand, silt, and clay in the surface layer of the soil. Most soils contain a mixture of sand, silt, and clay; it would be unusual to find a soil made up of only one of these. Soil textural classes denote the average or combined effect of the soil particle sizes in a given sample. In the laboratory, soil texture is determined by a mechanical process of separating the soil into groups of grain sizes.

Transparency No. 1

Each of the soil particles has a distinctive feel; with a knowledge of soil textural classes and some experience, students should be able to determine the texture of the soil. The student should work some moist soil in his hand. Sand particles will feel gritty and coarse and will mold: however, the molded sand may fall apart when the hand is opened. Silt particles are sticky and gummy in moist soils and floury in dry soils. As moist silt particles are worked between the thumb and index finger, they will stick together and fall off the finger in large pieces. Clay particles are very sticky. When worked between the thumb and index finger, clay will form a leaf of soil up to one inch in length before it falls off the finger.

For convenience in determining the textural name of a soil from the mechanical analysis, an equilateral triangle has been adapted.

Transparency No. 2

The textural triangle gives the percent of sand, silt, and clay in each of the textural classes.

B. Because of their large size, sand and large silt particles have a low specific surface, or a surface area per unit mass. Since most of the important chemical and physical–chemical reactions in soils take place at the particle surface, the amount of surface area affects the ability of soils to react to chemicals. Soils with a high percentage of large particles lack plasticity and cannot retain large amounts of water or nutrients. However, the organic matter content of these soils can be increased, thus increasing the amount of nutrients and moisture available to plants.

Soils containing a high percentage of clay or fine silt particles have greater chemical activity which is necessary to maintain good soil structure and to form soil aggregates.

C. Soil Structure

Soil structure, the arrangement of soil particles into various sizes and shapes, is important because it affects the soil tilth and management decisions made by the farmer. The particles in different type soils stick together differently and give the soil particles a different shape. The farmer can control the soil structure through his method of cultivation, time of cultivation, and by regulating the amount of organic matter lime. Good farmers try to keep their soils in a good state of tilth at all times.

Soils with a good structure contain a lot of crumbs or aggregates, which indicate good tilth. Good structured soil permits deeper root penetration and a greater area from which the plant can secure nutrients.

An example of two different types of soil structure could be obtained by taking a soil sample from an area with a dense, heavy growth of grass and taking a sample from a field that has been in continuous cultivation. The sample taken from the grassy area will be grainy and will contain a large amount of aggregates, while the sample taken from the field will be firm, hard, and will lack aggregates or crumbs.

Transparency No. 3

Soil scientists classify structural aggregates of soils into three main categories, based upon their shape, size, and strength.

The main soil structure types determined by the shape and arrangement of aggregates are granular, prismatic, blocky, and platy. Evidence of the soil structure types can usually be observed when a clod of soil is broken. If the cracks or lines of cleavage are mostly vertical, the soil has a prismatic or columnar structure; when cleavage is mostly horizontal, a platy structure exists; and when the cracks or cleavage are about equal, the soil has a blocky or granular structure.

Class of soil structure is determined by the size of the soil aggregates and they are commonly classed as coarse, medium, or fine. Size of soil aggregates varies with their shapes.

Grade of soil structure is determined by the strength of soil aggregates. Strength of the soil aggregate is measured by its resistance to crushing. Soils are considered to be structureless when the particles of coarse soil fail to cling together, or when fine soil breaks into large cementlike clods. Other descriptive grades of soil structure are weak, friable, and firm.

Transparency No. 4

In order to describe soil structure, scientists have named the shape of each kind of structure in which the particles arrange themselves differently. The six most common types of soil structure are single grain, granular, blocky, prismatic, platy, and massive.

Soil structure influences many important functions of the soil, such as the infiltration rate of water. Soils with a single grain or granular structure possess a rapid rate; soils with a blocky or prismatic structure have a moderate rate; and soils with a platy or massive structure have a slow rate of infiltration.

Since soil structure is important to soil management, the farmer or student should become familiar with the maintenance of good structure and the formation of aggregates or crumbs. Soil particles are grouped into aggregates by the action of complex sugars. While one part of the sugar arranges the soil particles loosely into clusters, another part is binding the particles firmly into aggregates. Before soil particles can be bound into aggregates, they must be grouped into loose clusters.

Flocculation, the first step in forming a soil aggregate, is caused by nature. Flocculation pulls the clay particles close together so that they are cemented with gum, which is made from soil sugars. The second step in aggregate formation is the binding of the clay particles in the flocs into aggregates.

The removal of plant cover from soil destroys aggregation and the sugars that bind the particles. The longer the soil is without a cover, the more breakdown there is in the aggregate. As plants cover the soil, aggregates start to rebuild and the breakdown stops.

D. Soil Consistence

Consistence refers to the cohesiveness of soil or its resistance to rupture or deformation. Soil consistence and structure are interrelated in that structure deals with the shape, size, and distinctness of natural aggregates, while consistence refers to the force required to rupture soil material.

Consistence may be described under moisture conditions of wet, moist, or dry soil. When the soil material is wet, consistence is described by its stickiness or plasticity. Consistence when soil is moist is characterized by its tendency to break into smaller masses, but its ability to cohere again when pressed together. The consistence of soil material when dry is characterized by brittleness, maximum resistance to pressure, and inability of crushed material to cohere again when pressed together.

E. Soil Fertility and Productivity

Soil fertility is the ability of the soil to provide nutrients for plant growth. Regardless of the level of soil fertility, plant food must be returned to the soil if the soil is to stay fertile. As plant nutrients in soils decrease, the plant growth declines.

The productivity of a soil is the present capability of that soil for producing a specified plant or sequence of plants, under a defined set of management practices. It is measured in terms of outputs, or harvests, in relation to production inputs—fertilizer, etc., for a specific kind of soil.

The capability of a soil under a particular system of management is dependant upon such factors as the soil's natural fertility, organic matter content, texture, structure, and climate.

REFERENCES:

1. Vanderford, H. B., Managing Southern Soils, John Wiley & Sons, Incorporated, New York, NY, 1957.

2. Soil, 1957 Yearbook of Agriculture, U.S.D.A., Washington, DC.

3. Jacks, L. P. and J. Roland Hamilton, Basic Principles of Soil Science, Agricultural Education Department, Mississippi State University, State College, MS, 1965.

4. Donahue, Roy L., Our Soils and Their Management, Third Edition, The Interstate Printers and Publishers, Inc., Danville, IL, 1970.

5. Donahue, Roy L., John C. Shickluna, and Lynn S. Robertson, Soils—An Introduction to Soils and Plant Growth, Third Edition, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971.

6. Knuti, Leo L., Milton Korpi, and J. C. Hide, Profitable Soil Management, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1962.

SOIL TEXTURAL CLASSES

SAND — DRY: LOOSE AND SINGLE GRAINED; FEELS GRITTY. MOIST: WILL FORM VERY EASILY-CRUMBLED BALL. SAND--85-100%, SILT--0-15%, CLAY--0-10%.

LOAMY SAND — DRY: SILT AND CLAY MAY MASK SAND; FEELS LOOSE, GRITTY. MOIST: FEELS GRITTY; FORMS EASILY-CRUMBLED BALL; STAINS FINGERS SLIGHTLY. SAND--70-90%, SILT--0-30%, CLAY--0-15%.

SANDY LOAM —DRY: CLODS EASILY BROKEN; SAND CAN BE SEEN AND FELT. MOIST: MODERATELY GRITTY; FORMS BALL THAT CAN STAND CAREFUL HANDLING; DEFINITELY STAINS FINGERS. SAND--43-85%, SILT--0-50%, CLAY--0-20%.

LOAM —DRY: CLODS MODERATELY DIFFICULT TO BREAK; MELLOW, SOMEWHAT GRITTY. MOIST: NEITHER VERY GRITTY NOR VERY SMOOTH; FORMS A FIRM BALL; STAINS FINGERS. SAND--23-52%, SILT--28-50%, CLAY--7-27%.

SILT LOAM —DRY: CLODS DIFFICULT TO BREAK; WHEN PULVERIZED FEELS SMOOTH, SOFT AND FLOURY, SHOWS FINGERPRINTS. MOIST: HAS SMOOTH OR SLICK "BUTTERY" OR "VELVETY" FEEL; STAINS FINGERS. SAND--0-50%, SILT--50-88%, CLAY--0-27%.

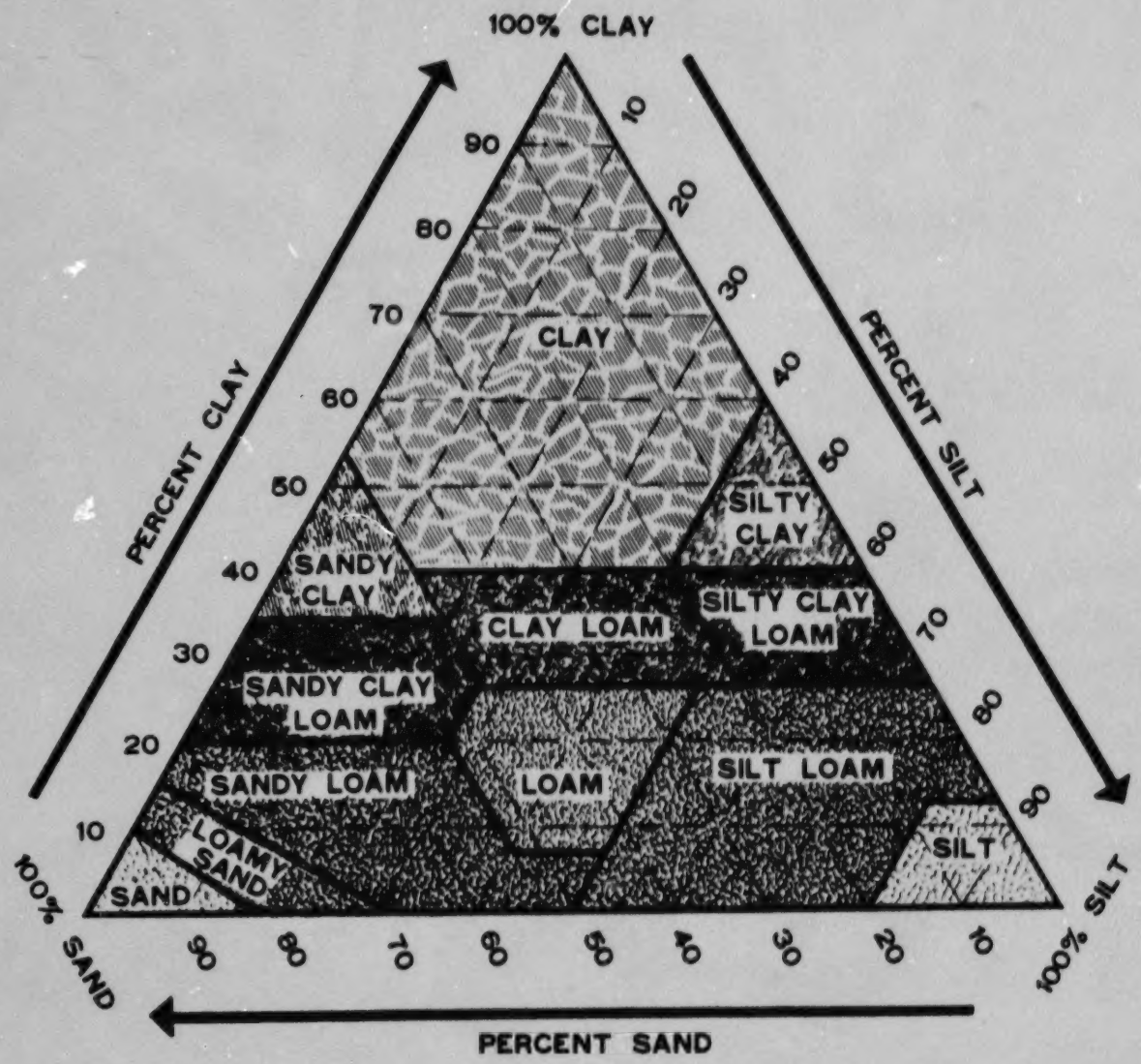
CLAY LOAM — DRY: CLODS VERY DIFFICULT TO BREAK WITH FINGERS. MOIST: HAS SLIGHTLY GRITTY FEEL; STAINS FINGERS; RIBBONS FAIRLY WELL. SAND--20-45%, SILT-15-53%, CLAY--27-40%.

SILTY CLAY LOAM —SAME AS ABOVE BUT VERY SMOOTH. SAND--0-20%, SILT--40-73%, CLAY--27-40%.

SANDY CLAY LOAM —SAME AS FOR CLAY LOAM. SAND--45-80%, SILT--0-28%, CLAY--20-35%.

CLAY — DRY: CLODS CANNOT BE BROKEN WITH FINGERS WITHOUT EXTREME PRESSURE. MOIST: QUITE PLASTIC AND USUALLY STICKY WHEN WET; STAINS FINGERS. (A SILTY CLAY FEELS SMOOTH, A SANDY CLAY FEELS GRITTY.) SAND--0-45%, SILT--0-40%, CLAY--40-100%.

Soil Triangle



V. A. I

III-B-2
No. 2

CATEGORIES FOR CLASSIFYING STRUCTURAL AGGREGATES OF SOILS

Type of Soil Structure

(shape & arrangement of aggregates)

1. GRANULAR
2. PRISMATIC
3. BLOCKY
4. PLATY

Class of Soil Structure

(size of aggregates)

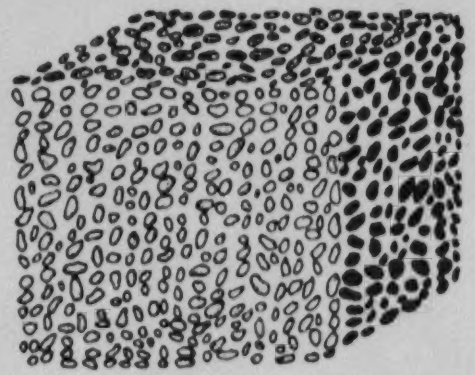
1. COARSE
2. MEDIUM
3. FINE

Grade of Soil Structure

(strength of aggregate)

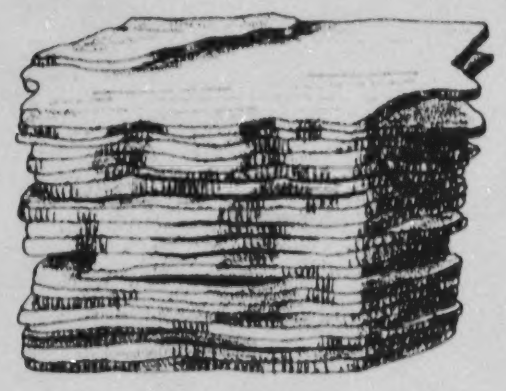
1. STRUCTURELESS
2. WEAK
3. FRIABLE
4. FIRM

Soil Structure

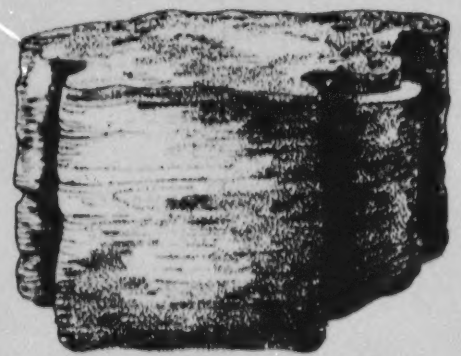


SINGLE GRAIN

BLOCKY



PLATY



MASSIVE

GRANULAR

PRISMATIC

SOIL SCIENCE

Unit B: Nature and Properties of Soils

Topic 3: Soil Classification

Note: A map of the United States showing the kinds of soils, orders, suborders, and great groups is available from the United States Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202.

***All terms underlined are included in the "Glossary of Terms."**

I. Soil Classification

In order for soil scientists to study soils, there had to be some system of soil classification and identification. The scientist recognizes a soil by its features, the same way an individual is recognized.

Classification consists of an orderly grouping of defined kinds of soils into classes in a system designed to make it easier to remember their characteristics. The purpose of the classification of soils is to place them into suitable categories to study and interpret their interrelationships or inherent problems. Land use and other principles of treatment can then be determined and applied to each class of land.

Since the features of the soil are found in the soil profile, one must be familiar with the soil profile in order to classify soils.

II. Soil Profile

Transparency No. 1

A soil profile is a vertical section of the soil extending down through all of its horizons—"A," or topsoil; "B," or subsoil; and "C," or parent materials, which is the layer just above solid-earth bedrock. These horizons often merge with one another, and therefore may not be easily identified. The horizons of a particular soil vary in one or more properties such as texture, color, structure, consistency, porosity, and reaction. By studying these variations and properties, it is possible to identify soils.

The depth of each horizon in a soil profile varies in accordance with the several factors which originally influenced its formation. Some are thick, some thin, varying from less than an inch to several feet.

Transparency No. 2

Soil horizons vary in thickness and generally are merged with one another; therefore, the horizons usually lack sharp boundaries. Most soil profiles include three master horizons, identified by the letters A, B, and C; however, some soils lack a B horizon and are said to have AC profiles. Eroded soils may not have an A horizon, and in some cases the B horizon may have eroded away.

"A" HORIZON or TOPSOIL—The soil on the surface makes up this horizon, unless this layer has been completely eroded away. The "A" horizon is the soil layer where life is most abundant in the form of plant roots, bacteria, fungi, and insects. It is the layer usually cultivated for crops.

All of the master horizons may be subdivided in the scientific study of soils. Such subdivisions are identified by the proper letter plus a subscript number, thus: A_1, A_2, A_3, etc. The subdivisions of master horizons provide clues to the processes of soil formation and are important to the use and management of the soil.

The subdivisions of the "A" horizon are as follows:

A_{00}—Loose leaves and organic debris, largely undecomposed.
A_0—Organic debris partially decomposed or matted.
A_1—A dark-colored horizon with a high content of organic matter mixed with mineral matter
A_2—A light-colored horizon of maximum eluviation. Prominent in podzolic soils.
A_3—Transitional to B, but more like A than B. Sometimes absent.

"B" HORIZON or SUBSOIL—The "B" horizon is the layer of soil lying just beneath the "A" horizon and is referred to as the subsoil. It contains more clay and less organic matter than the topsoil.

The "B" horizon forms partly by the downward movement of the finer soil particles during the percolation of soil water. Organisms and plant residues have very little influence on the formation of the "B" horizon. Neither does cultivation, except where there is some mixing of topsoil with the "B" horizon. Therefore, the characteristics of the subsoils are usually an accurate index to their true nature and origin.

The subdivisions of the "B" horizon are as follows:

B_1—Transitional to B, but more like A than B. Sometimes absent.
B_2—Maximum accumulation of silicate clay materials or of iron and organic matter; maximum development of blocky or prismatic structure; or both.
B3—Transitional to C.

The combined "A" and "B" horizons, the major part of a soil profile, are called the solum or true soil. This is the area that supports plant growth.

"C" HORIZON or PARENT MATERIAL—The "C" horizon is the layer of loose parent material lying between the "B" horizon and earth bedrock. Parent materials are important not only because they affect the formation of subsoils above them,

but because they are directly associated with the texture and natural fertility of any soil. The "C" horizon has less living matter than overlying ones and is therefore lower in organic matter. It is commonly lighter in color than "A" and "B" horizons.

The subdivisions of the "C" horizon are as follows:

G—Horizon G for intensely gleyed layers, as in hydromorphic soils.

Cca and Ccs—The weathered parent material. These horizons are layers of accumulated calcium carbonate and calcium sulfate found in some soils.

"D" HORIZON or BEDROCK—The "D" horizon is any stratum underneath the soil, such as hard rock or layers of clay or sand, that are not parent material, but which may have significance to the overlying soil.

III. Classifying Soils

People have always classified soils by their colors, water holding capacity, or by some other characteristic, but this wasn't very specific or exact.

Transparency No. 3

To take advantage of soil research and to increase yields, soil scientists had to classify soils according to a scheme. The soil classification scheme being used at the present time is grouped as follows:

Order	Subgroup	Class
Suborder	Family	Type
Great Group	Series	Phase

The following is an explanation of each of the above groups:

A. Order—The soil order is the highest and most general level of soil classification. At present, 10 soil orders are used. The orders reflect in a general way geographic distribution of soils similar in degree and kind of horizon development. ENTICOLS, for instance (found in a small area in West Texas), lack well defined genetic horizons, while ULTISOLS are weathered to an advanced stage and have horizons strongly contrasting in color.

B. Suborder—The suborder, a division of the soil order, groups soils which have common characteristics reflecting uniformity in the soil forming factors. For example, AQUALFS are seasonally wet ALFISOLS that are gray and mottled.

C. Great Group—The great group is a further subdivision of the suborder, and provides for grouping soils largely on the presence or absence of diagnostic horizons and their arrangement. For instance, MOLLISOLS that contain significant alluvial clay are called ARGIUSTOLLS.

D. Subgroup—At the subgroup level soils with properties typical of the great group are classified together.

E. Family--Soils similar in texture below the surface layer and similar in clay mineralogy, temperature, and other properties are grouped in the same soil family. Houston Black clay is in the fine, montmorillonitic, thermic family of Udic Pellusterts.

F. Series--Soils essentially uniform in kind, thickness, and sequence of horizons and very similar physically, chemically, and mineralogically are called a soil series. This is the lowest category of formal soil classification. Houston Black is an example of a series name. The series name usually derives from the place where the soil was first found. There are approximately 8,000 soil series in the new classification system.

G. Textural Class--The textural class is determined by the percentage of sand, silt, and clay in the surface layer of the soil. The surface texture is allowed to vary more than other properties.

H. Type--There are approximately 80,000 soil types in the United States, and the series name combined with the textural name is the soil type. An example of soil type would be Norfolk, fine, sandy loam.

I. Phase--Phases are individual areas of soil types which have differences in slope, stoniness, and thickness due to erosion. For example, Pullman clay loam, 0-1 percent slopes is a soil phase.

Transparency No. 4

Differences among soil types occur even within the boundaries of small farms. Each soil type can be defined by a description of the typical profile, the allowable differences from that profile, and other features such as slope, stoniness, and physiographic position.

Similar soil types always occur in a definite geographic area and in the same formations. In other words, they always choose the same neighbors. The individual bodies of neighboring soil types within a farm fit together like the pieces of a jigsaw puzzle as shown in the illustration. However, soil types are not set apart as distinctly as the sketch suggests; they grade into one another without sharp boundaries between them. This is one reason why soil appears to be a continuous mantle over the land surface.

IV. Soil Surveys

Soil classification and identification are important in order for farmers to make decisions necessary to secure maximum production. The information obtained by soil scientists in classifying and identifying various soils is recorded in a soil survey. A soil survey is a map of a farm that designates the kinds and location of soils. It also gives a description of the soils along with suggestions as to their use and management.

Soil surveys should be made by an experienced person such as a local S.C.S. technician. The first step in making the survey is to secure an aerial map of the area to be surveyed. After a thorough study of the map, the technician takes soil samples and determines the texture, color, and thickness of each layer of soil in order to classify and identify the soils. To complete the survey, the technician draws lines on the aerial photograph to designate changes in soil. The soil map will also designate soil types, erosion, slope, and land capability classes. All of this information is necessary for proper soil management and maximum production.

V. Conservation Plans

Transparency No. 5

In order for the landowner to derive the maximum benefit from a soil survey report, he should secure the services of the local Soil Conservation Service personnel to assist him in developing a soil and water conservation plan for his farm or ranch. The conservation plan consists of a plan map (aerial photograph) of the individual farm and a soil survey map. The conservation plan represents a cooperative agreement between the landowner and the Soil Conservation Service District. It reflects the landowner's decisions on how to use the land based on sound land use and economy of operations.

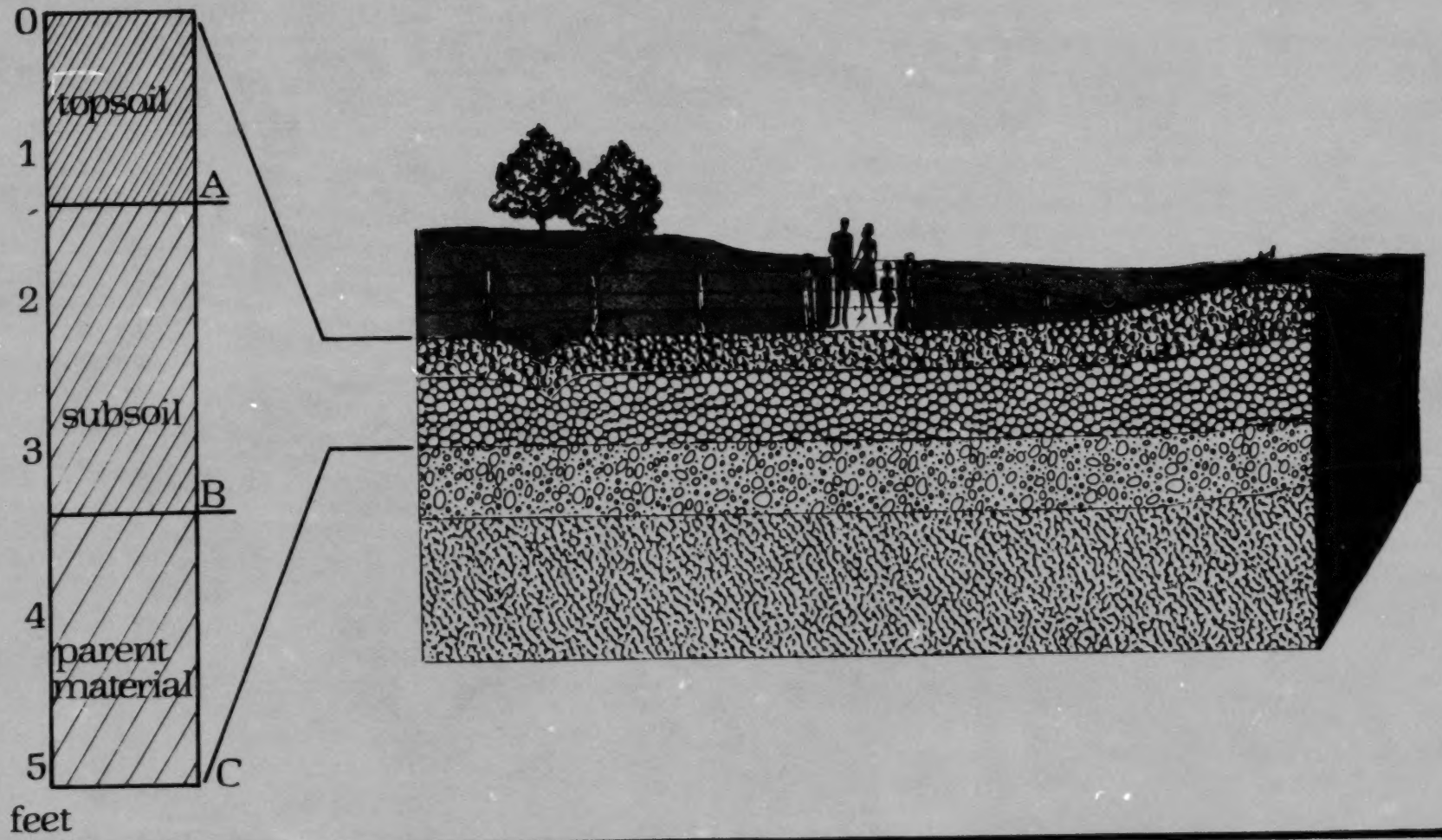
The conservation plan, after being completed will serve as a guide for soil and water conservation improvements to be carried out by the landowner for several years. The Soil Conservation Service then provides technical assistance at no cost to the landowner for putting the plan into operation and in making needed changes in the plan.

REFERENCES:

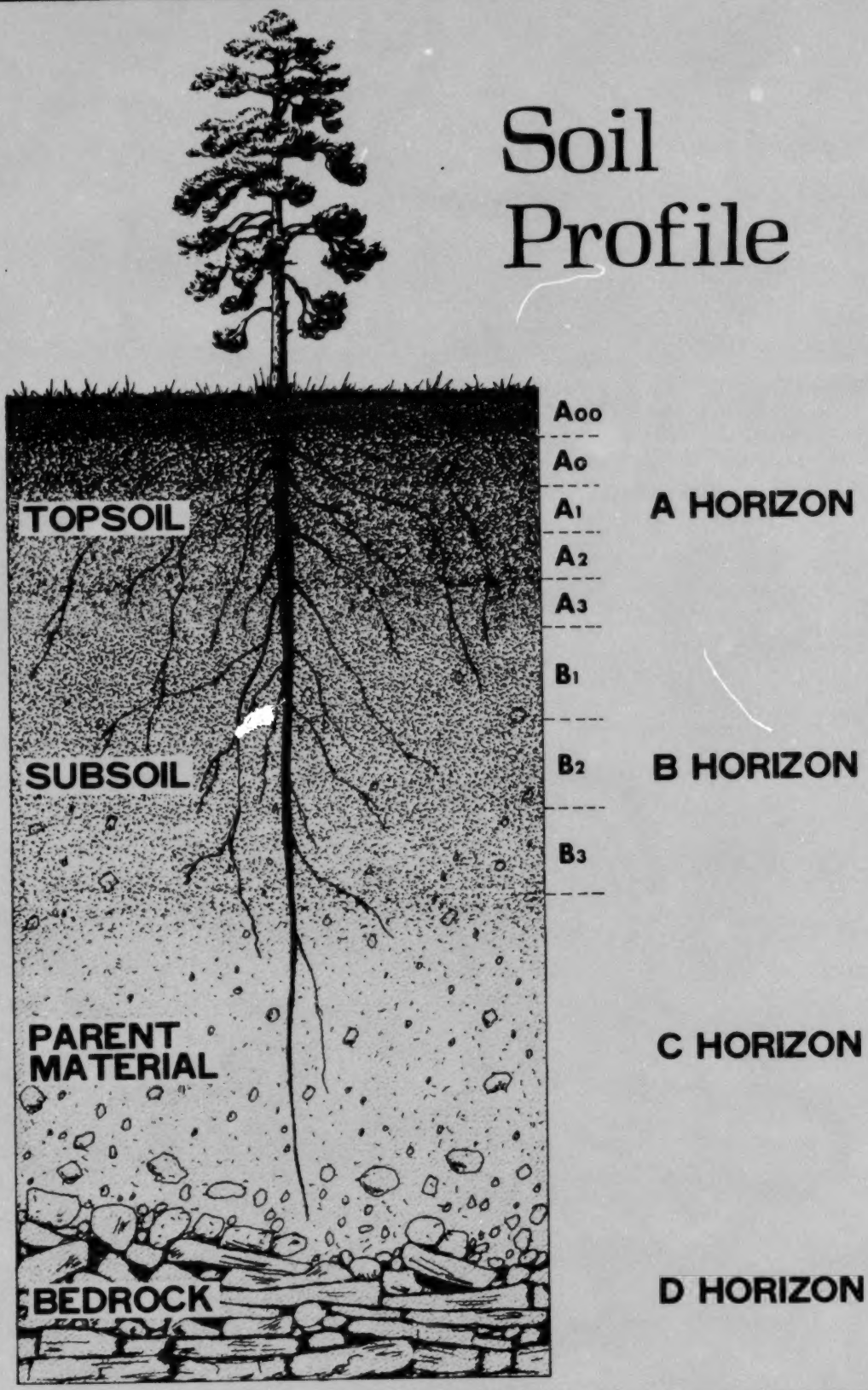
1. Soil, 1957 Yearbook of Agriculture, U.S.D.A., Washington, DC.

2. Vanderford, H. B., Managing Southern Soils, John Wiley and Sons, Inc., New York, NY, 1957.

SOIL PROFILE



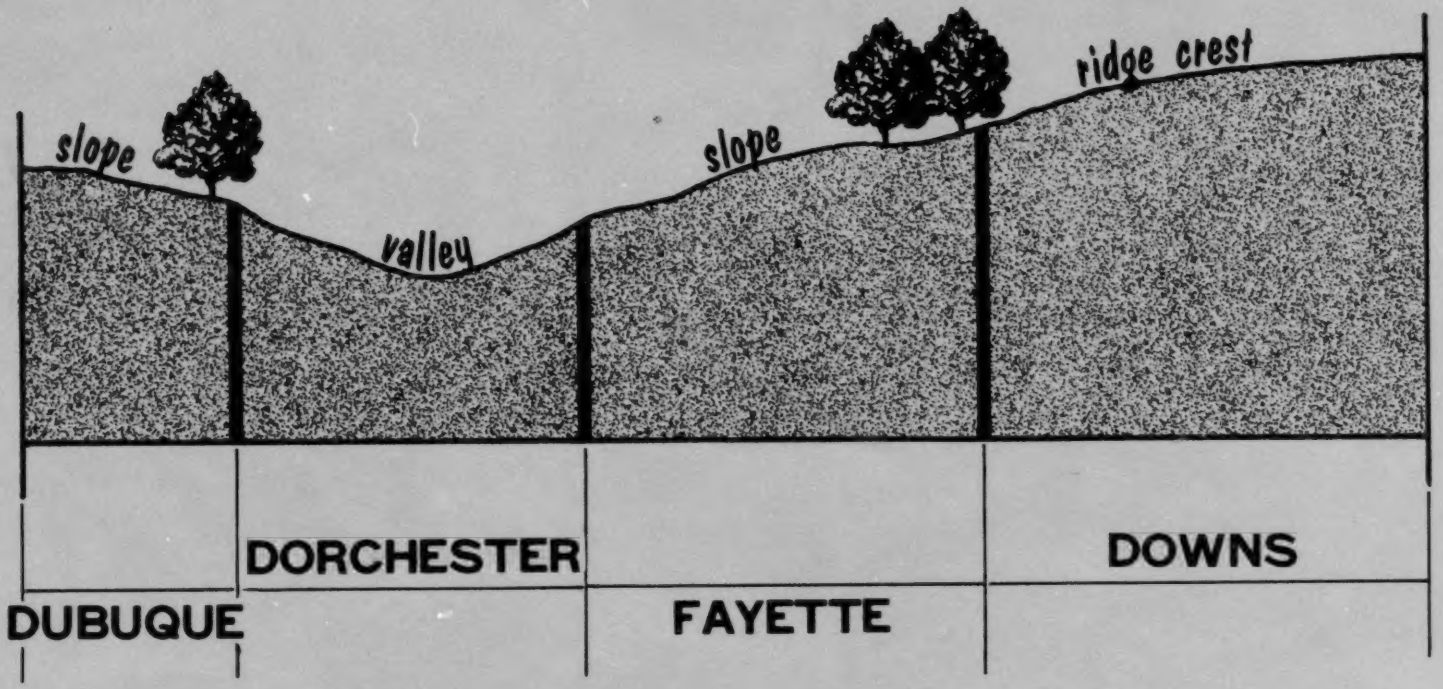
Soil Profile



SCIENTIFIC CLASSIFICATION OF A SOIL SAMPLE

ORDER	ALFISOLS
SUBORDER	USTALFS
GREAT GROUP	PALEUSTALFS
SUBGROUP	VERTIC ALBAQUALFS
FAMILY	FINE, MONTMORILLONITIC
SERIES	TABOR
TEXTURAL CLASS	FINE SANDY LOAM
TYPE	TABOR FINE SANDY LOAM
PHASE	1-3 PER CENT SLOPES

How Soil Types Fit Together



SOIL & WATER CONSERVATION PLAN

A. CONSERVATION PLAN MAP (AERIAL PHOTOGRAPH)

B. SOIL & WATER CAPABILITY MAP

C. RECORD OF COOPERATOR'S DECISIONS & PROGRESS IN APPLICATION

1. FIELD NUMBERS
2. LAND USE & TREATMENT
   a. PLANNED
   b. APPLIED

D. ANNUAL GRAZING PLAN

E. FORAGE INVENTORY

F. FARMER - SOIL CONSERVATION DISTRICT COOPERATIVE AGREEMENT

SOIL SCIENCE

Unit B: Nature and Properties of Soils

Topic 4: Soil Sampling

Suggested Procedure and Activities: It may be helpful to devote one class period to actually taking a soil sample in the field.

*All terms underlined are included in the "Glossary of Terms."

I. Introduction

The soil in some respects is like people; it needs a periodic check up. It is through this periodic check up, along with good management practices, that the highest return on the investment in fertilizer and lime can be acquired. In order to know the proper amount of fertilizer and the lime the soil needs, the soil should be tested. The soil test will provide a scientific basis, rather than a haphazard hit-and-miss basis, for correct usage.

There are thousands of soil samples taken each year. The results of the sample test will indicate the necessary facts and recommendations concerning the soil. The test results will make available facts that will indicate whether the soil needs:

A. Lime
B. Nitrogen
C. Phosphorus
D. Potassium

The test will further determine the levels of calcium, magnesium, zinc, iron, manganese, and the percent of organic matter in the soil. Also, it will indicate if the soil has sufficient salt content to create a salinity hazard.

In addition to the above information obtained from the chemical test, the soil testing laboratories analyze the information supplied from the landowner and suggest fertilization and liming rates compatable with the desired production.

II. The Proper Time to Take Soil Samples

A. Samples may be taken any time during the year.
B. The sample should be taken when the soil is dry enough to work readily.
C. The season of the year may assist in obtaining the test results.
   1. It is recommended to take samples in the fall for spring planted crops.
   2. Sample in the summer for fall planted crops.
D. Take samples well in advance of the time the crop is to be planted. This practice will allow the testing laboratory ample time to return the results.
E. Soil samples should be made as a general rule:
   1. Once a year, for continuous row crops.
   2. Once per rotation of dairy farm rotation.

III. Procedure in Taking a Soil Sample

Transparency No. 1

A. Get Complete Information—There are two important sayings:

(1) Don't guess, soil test.
(2) The soil test is only as good as the soil sample.

When taking a soil sample, be sure you have the information needed for taking the sample. Information may be obtained from the vocational agriculture teacher or other local agricultural authorities in the county. The procedure in taking a soil sample may vary from state to state or even from county to county, due to local situations. The instructions on how to take a proper soil sample should be studied and followed very carefully.

B. Select Proper Sampling Tools—A soil probe or auger is highly recommended for obtaining soil. If the soil probe or auger is not available, a garden trowel or spade may be used. A perfectly clean pail (bucket) is recommended for collecting the soil from each sample area. Feed dealers and agricultural authorities often have these tools to loan.

Transparency No. 2

C. Watch for Unusual Areas—When taking a soil sample, avoid old fence lines, dead furrows, old manure and lime piles, terrace channels, snow fences, back furrows, windbreaks, wet spots, areas near trees, areas near the boundaries between slopes and bottomland, and areas near lime-rock roads.

D. The field to be sampled should be divided into different areas. It is usually recommended that each sample represent an area of not more than 8 to 12 acres. In areas where soil is uniform, it may be possible to use larger acreage per sample area. Be sure and sample separately all areas that have different crop growth, soil color, and past management. It would be wise to avoid all areas that are too small to be limed or fertilized separately.

Transparency No. 3

E. Take composite samples of soil from each area. The first thing that should be done after a sampling area is designated is to remove the surface litter from the spot sample that is to be made. Soil should be taken from 10 to 15 spots in each area. As the soil is taken, it should be placed in a clean pail. The soil that is taken from a row crop field should be obtained between the rows and not from rows. If the samples are being taken on pasture areas take only about the top two to four inches of the topsoil.

F. When a sample is taken with a spade, a V-shaped hole should be dug to plow depth. Remove a ½-inch slice of soil from the face of the hole. Remove all except the middle inch of the soil slice. Place the one inch slice in a clean pail.

Transparency No. 4

G. Mix Soil from Sample Spots—The soil taken from the sampling spots in each area should be mixed well in a clean pail. It is advisable to remove as much foreign matter as possible without changing the representative sample.

H. Fill out the Information Sheet—The extent of accuracy of the test results will depend not only upon the composite sample but also the information given about the sample. For instance, fertilizer rates will depend on the soil type, crop to be grown, normal moisture situation and expected yield.

Transparency No. 5

I. Identify Samples and Keep Records—Many times it is good to make a rough sketch of the areas of fields sampled and correspond them by number to an assigned number on the sample carton.

J. Follow Recommendations—The soil test will be of little value if it is not followed. The soil test results and recommendations should be studied carefully. The fertilizer dealer, vocational agricultural teacher, or other agricultural authority in the community can be of great assistance in helping you properly carry out your program.

IV. Where to Send Soil Samples for Testing

There are several places in Texas to send soil samples. It is recommended that contact be made with local agricultural authorities to secure information concerning the nearest soil testing laboratory in the area. Remember that all laboratories do not offer special tests that may be desired.

V. Sample Carton and Information Sheet(s)

Soil sampling information should be filled out completely on the mailing carton. It is very important that the proper information sheet be enclosed in the mailing carton, or attached to a letter outside the mailing carton. The information sheet should be filled out as completely as possible. There are examples of the different types of information sheets, according to the test, crop, and etc., desired. The information sheets included in this lesson are:

a. Soil sample information sheet for field crops.
b. Information sheet for salinity analysis of soil samples.
c. Information sheet on soil samples for research purposes.
d. Soil sample information sheet for lawns, gardens, and flower beds.

These information sheets are the most commonly used throughout the state.

There are other special information sheets. For example, there are information sheets for:

a. Pecan leaf samples
b. Greenhouse tomato leaf samples
c. Rice soil samples
d. Irrigation water analysis

These information sheets may be obtained by writing to:

Texas A&M University
Texas Agricultural Extension Service
Soil Testing Laboratory
College Station, TX 77843

or contact your local agricultural authority.

REFERENCES:

1. "Test Your Soil for Profit," L-265, Texas Agricultural Extension Service, College Station, TX 77843.

2. Welch, C. D., Carl Gray, and others, Texas Soil Fertility, Texas Agricultural Extension Service and Texas Plant Food Institute, College Station, TX 77843.

TEXAS A&M UNIVERSITY
TEXAS AGRICULTURAL EXTENSION SERVICE
SOIL TESTING LABORATORY

ASCS Farm No.

SOIL SAMPLE INFORMATION SHEET FOR FIELD CROPS

To aid in interpreting the soil test and making recommendations, fill in the following information sheet as completely as possible and submit with your soil samples. Each soil sample should be marked with your name and sample number which should correspond with the information furnished on this sheet. See mailing instructions on opposite side under Step 4. (Do not send cash)

NAME _____ Date _____

ADDRESS _____ County _____

POST OFFICE _____ Zip _____

EXTRA COPY TO: NAME _____

ADDRESS _____

CHECK ONE

Regular tests
$2.00 per sample

Regular tests plus
iron, zinc and manganese
$5.00 per sample

A. SOIL CONDITIONS: (Use ditto and check marks wherever possible)

Laboratory number (Do not write in this column)	Your sample number	Location		To be irrigated		Limed during last 2 years		Remarks (Soil type or condition, problem)
		Upland	Bottom	yes	no	yes	no	

B. CROPS TO BE GROWN

C. CROPPING AND FERTILIZATION HISTORY

Your sample number	Next crop to be fertilized		Present or last crop 197			
	Crop or forage	Desired yield	Crop or forage	Yield	Fertilizer	
					Grade	Lb./A

D. GENERAL: (Please answer following questions **if they apply to these samples.**)

1. Will small grain be grazed? No _____ Yes _____ Which fields? _____
2. Will grass be used for hay only? No _____ Yes _____ Which fields? _____
3. Will grass be used for grazing only? No _____ Yes _____ Which fields? _____
4. If grazed, how many acres per animal unit is desired stocking rate? _____
5. Will a legume be grown in pasture? No _____ Yes _____ Which fields? _____
   If so, what? _____
6. What is the primary grass to be grown for pasture or hay on the fields sampled?
   Common Bermuda _____ Bahia Grass _____
   Coastal Bermuda _____ Love Grass _____
   Dallis Grass _____ Klein Grass _____
   Harding Grass _____ Native Range Grass _____
7. Is a grass to be newly established on the sampled area? No _____ Yes _____
8. Is a minimum recommendation for ASCS needed? _____

THE A&M COLLEGE OF TEXAS
TEXAS AGRICULTURAL EXTENSION SERVICE
SOIL TESTING LABORATORY

INFORMATION SHEET FOR SALINITY ANALYSIS OF SOIL SAMPLES

To aid in interpreting the results of the salinity analysis, fill in the following information sheet as completely as possible and submit with your soil samples. Mark each sample plainly with your name and sample number to correspond with the information furnished below. See the reverse side of this sheet for costs and procedure for sample collection and mailing.

NAME..... COUNTY.....

ADDRESS..... LOCATION IN COUNTY.....
(NE, S, SW, W, NW, , etc.)

POST OFFICE..... DATE.....

EXTRA COPY TO: NAME.....

ADDRESS.....

SAMPLES TAKEN BY:
Farmer.....
Co. Agt.....
Dealer.....
ASC.....
SCS.....
Vo-Ag.....
4-H.....

A. SOIL CONDITIONS: (Use ditto and check marks wherever possible)

Laboratory Number (Do not write in this space)	Your Sample Number	Acres in Sample	No. of Locations per Sample	Depth of Sample	Slope			Internal Drainage			Location			Physical Condition					Depth of Topsoil Heavy Subsoil	Soil Type (If known)
														Topsoil			Subsoil			
					Level	Slight	Moderate	Good	Fair	Poor	Upland	Bottom	2nd Bottom	Loose	Mellow	Tight	Loose	Tight		

B. CROPPING HISTORY

1. List crops grown and yield for the past 3 years. 196.....? ..... 196.....? ..... 196.....? .....
2. List crops you plan to grow.....
3. List rate, kind and method of application of fertilizer on the affected crops.....

.....

C. GENERAL

1. How long has land been cultivated?..... How long irrigated?.....
2. Is there a high water table? Yes..... No..... If so, give depth to water table.....
3. What is the source of irrigation water?..... Has it been analyzed?.....
4. Have any soil amendments (gypsum, sulfur, sulfuric acid, limestone) been applied?.....
   How much?..... When?.....
5. Describe any difficulties you have on this area.....

.....

6. Describe plant growth symptoms on salt affected area.....

.....

SEND A COPY OF YOUR LATEST WATER ANALYSIS WITH THESE SAMPLES IF AVAILABLE.

PROCEDURE FOR TAKING SOIL SAMPLES FOR SALINITY ANALYSIS

GENERAL

Each sample submitted should be a composite from a representative area. Take at least 10 small samples and mix thoroughly. From this, take about 1 quart for the composite samples. For land that is bedded for row crops, take samples in the furrow. Samples can be taken with a soil auger, soil probe or spade.

GENERAL FIELD SAMPLING

To determine whether a salinity problem exists in a field where it is not obvious, use the standard soil sampling procedure. This consists of sampling each uniform area or soil type within a field. Take a separate composite sample of each soil type as suggested above.

SAMPLING TROUBLE SPOTS

When sampling trouble spots (poor growth, barren spots, etc.), sample the bad area and also sample the surrounding good area. Keep these two samples separate for thorough analysis of the situation. Composite samples should be taken from at least 2 depths of 0-12 and 12-24 inches. Sampling at deeper depths may be desirable for orchards and deep rooted plants.

POOR SEED GERMINATION OR SEEDLING GROWTH

To determine if poor germination or poor seedling growth is due to salt, a composite sample can be taken from the seed area. Remove the surface crust and take samples from the 1 to 4-inch depth directly in the row.

SAMPLING ORCHARD SOILS

Some fruit and nut trees are sensitive to salt accumulations. Composite samples from 0-12, 12-24, 24-36 and 36-48 inches in depth need to be taken. If there is a trouble spot, take samples from this area and also sample the surrounding good area.

MAILING PROCEDURE AND COSTS OF TESTING

Place samples in a waxed sack or carton if available, securely package and mail to Soil Testing Laboratory, Texas Agricultural Extension Service, College Station, Texas, together with the information sheet and soil testing fee. The fee for a salinity analysis of soil is $4.00 per sample.

INFORMATION SHEET ON SOIL SAMPLES FOR RESEARCH PURPOSES

Date .....

Unit of TAES ..... Address .....

Individual to whom results should be sent .....

Date samples collected ..... Project no. .....

Soil type .....

Past cropping history .....

Past fertilizer use .....

Nature of study and crop .....

Should fertilizer recommendations be made from current year? .....

Additional information for off-station trials:

Farmer cooperator .....

County .....

Lab. no.	Field or sample no.	Depth of sample	Lab. no.	Field or sample no.	Depth of sample	Lab. no.	Field or sample no.	Depth of sample
					46			

TEXAS AGRICULTURAL EXTENSION SERVICE
THE TEXAS A&M UNIVERSITY SYSTEM
SOIL TESTING LABORATORY

SOIL SAMPLE INFORMATION SHEET FOR LAWNS, GARDENS AND FLOWER BEDS

This form is to be used for lawns, gardens and flower beds. Please fill out as completely as possible and mail with the soil samples. See opposite side for instructions on how to take samples and instructions for mailing. Be sure to enclose a check or money order for correct amount of fee.

NAME_____

ADDRESS_____

COUNTY_____ Date_____

POST OFFICE_____ Zip_____

Cost per sample (check)

Regular tests $2.00_____

Regular tests plus iron, zinc and manganese $5.00_____

Laboratory number (do not write in this space)	Your sample number	Condition of topsoil				Remarks
		Loose	Heavy	Packed	Mellow	(soil conditions)

Your sample number	Commercial fertilizer used		Organic material used (manure, compost, etc.)		Plants to be grown (lawn, vegetables, flowers, shrubs, trees)
	Kind	How much	Kind	How much	

Give size of area (dimensions or number of square feet):_____

How many years has garden (or lawn or flowers) been in this spot?_____

Do you have manures, compost, leaves or other organic material available each year? (Yes or No)_____ If so, how much?_____

What particular difficulties do you have with plant growth in this area?_____

INSTRUCTIONS FOR TAKING SOIL SAMPLES
from
Lawns, Gardens and Flower Beds

Soil tests can be only as accurate as the samples on which they are made. Therefore, proper collection of samples is extremely important.

Step 1.

Take at least one separate composite sample for each soil difference or soil condition. Differences can be due to texture, slope, color, drainage or past treatment. For example, if one area is sandy and another is heavier, take 2 separate composite samples. (Note: If sample is taken from problem area, such as bare spots in lawn, it is necessary that one composite sample come from the problem area, and one composite sample from the surrounding good area. See note on plant diseases below.)

Step 2.

For a composite sample, obtain at least 10 samples from the area, put in a clean container (bucket, sack, etc.) and mix thoroughly. Take out about 1 pint. Place in a clean container, such as an ice cream carton or paper sack, and submit for testing.

Step 3.

To take a sample, use a garden trowel or spade. Dig a V-shaped hole, then take a ½-inch slice from the smooth side of the hole. Place in a bucket and repeat in about ten places. Take samples to a depth of 6 inches in flower beds and gardens and 4 inches in lawns. A soil probe or soil auger also can be used.

Step 4.

Label each sample with number and name. Be sure to keep a record of the area from which the samples came. Fill out the opposite side of this sheet as completely as possible and submit with the sample to the Soil Testing Laboratory.

Note on Plant Diseases

If grasses, vegetables or flowers die, it is very seldom due to a lack of soil fertility, but is probably due to some other factor. If this is the case, a soil test would be of little value. If difficulties in plant growth appear to be due to diseases, see your county Extension agent for diagnosis and further information.

Educational programs conducted by the Texas Agricultural Extension Service serve people of all ages regardless of socio-economic levels, race, color, sex, religion and national origin.

MAILING INSTRUCTIONS

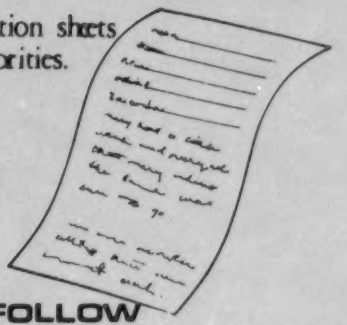
For each soil sample to be tested there will be a charge of $2 or $5 (see front). MAKE REMITTANCE PAYABLE TO SOIL TESTING LABORATORY. Place remittance and Information Sheet in an envelope and attach this envelope to package containing the sample or samples to be tested so that all the material will reach the Laboratory at the same time. Address to: Soil Testing Laboratory, Texas Agricultural Extension Service, The Texas A&M University System, College Station, Texas 77843, or to Soil Testing Laboratory, County Extension Office, Texas Agricultural Extension Service, Seymour, Texas 76380, or to Soil Testing Laboratory, Texas Agricultural Extension Service, Route 3, Lubbock, Texas 79401. Envelope containing remittance and Information Sheet will require first-class postage; package containing soil sample or samples may be sent parcel post.

FOR FURTHER DETAILS CONSULT YOUR COUNTY EXTENSION AGENT

SOIL → Sampling

A

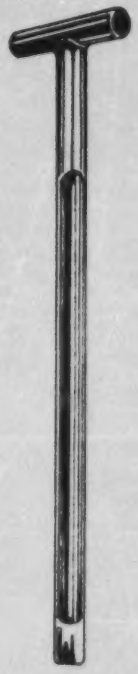
Obtain cartons and information sheets from local agricultural authorities.



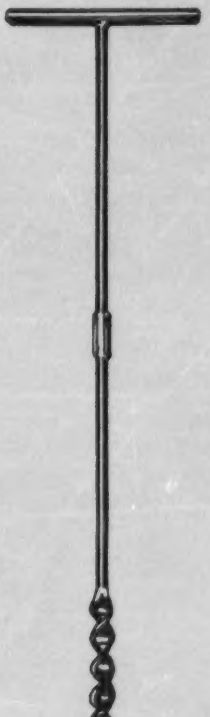
FOLLOW INSTRUCTIONS CAREFULLY

B

Soil Probe



Soil Auger



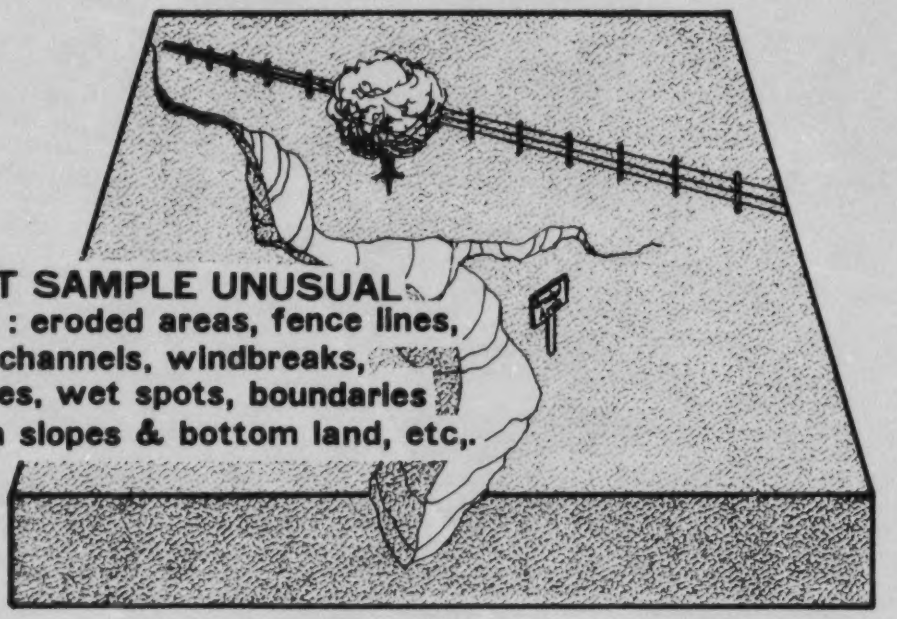
Spade or Shovel

Garden Trowel

SAMPLING TOOLS

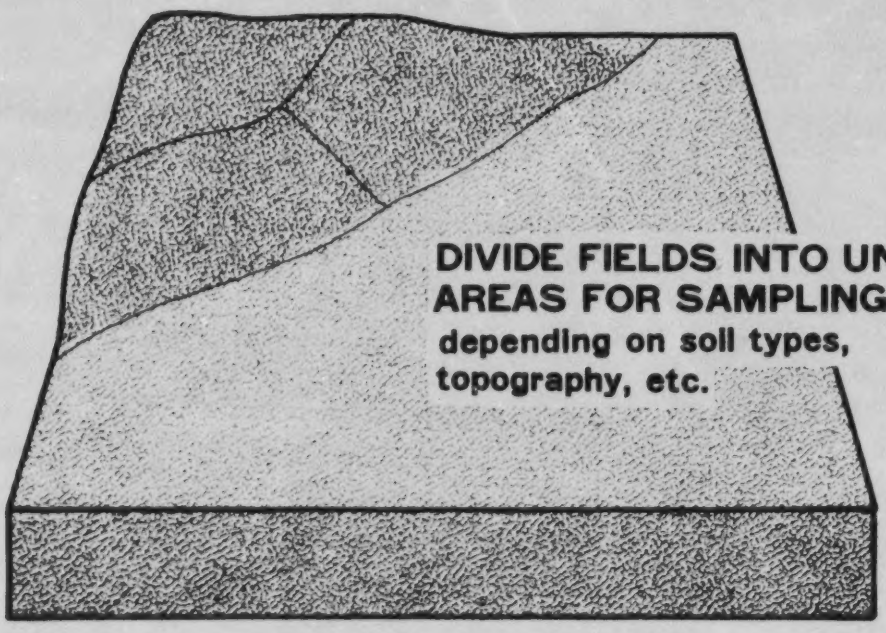
SOIL SAMPLING

C



DO NOT SAMPLE UNUSUAL AREAS : eroded areas, fence lines, terrace channels, windbreaks, near trees, wet spots, boundaries between slopes & bottom land, etc,.

D

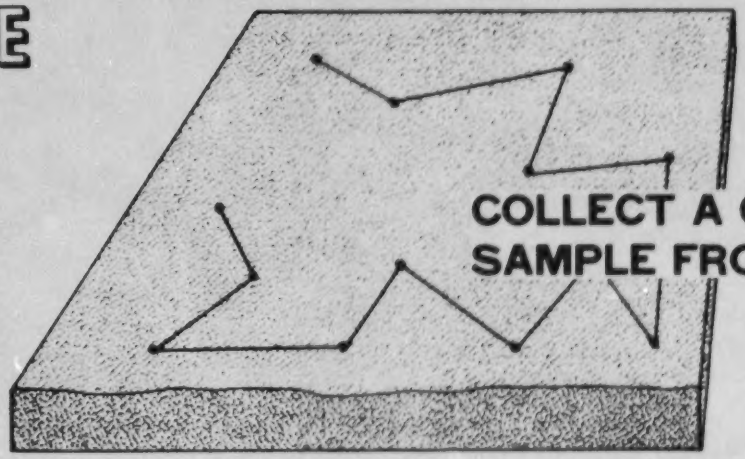


DIVIDE FIELDS INTO UNIFORM AREAS FOR SAMPLING
depending on soil types, topography, etc.

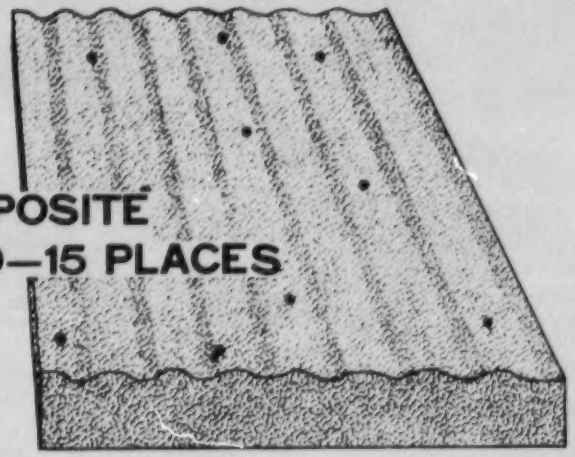
SOIL SAMPLING

PASTURE AREA

E



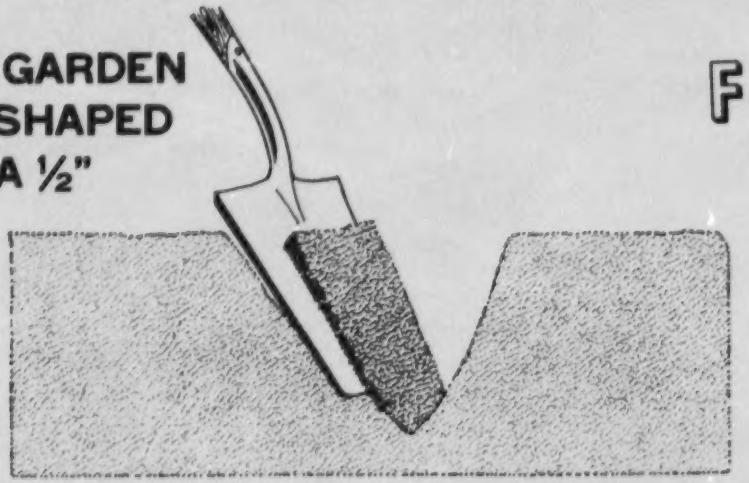
FIELD CROP AREA



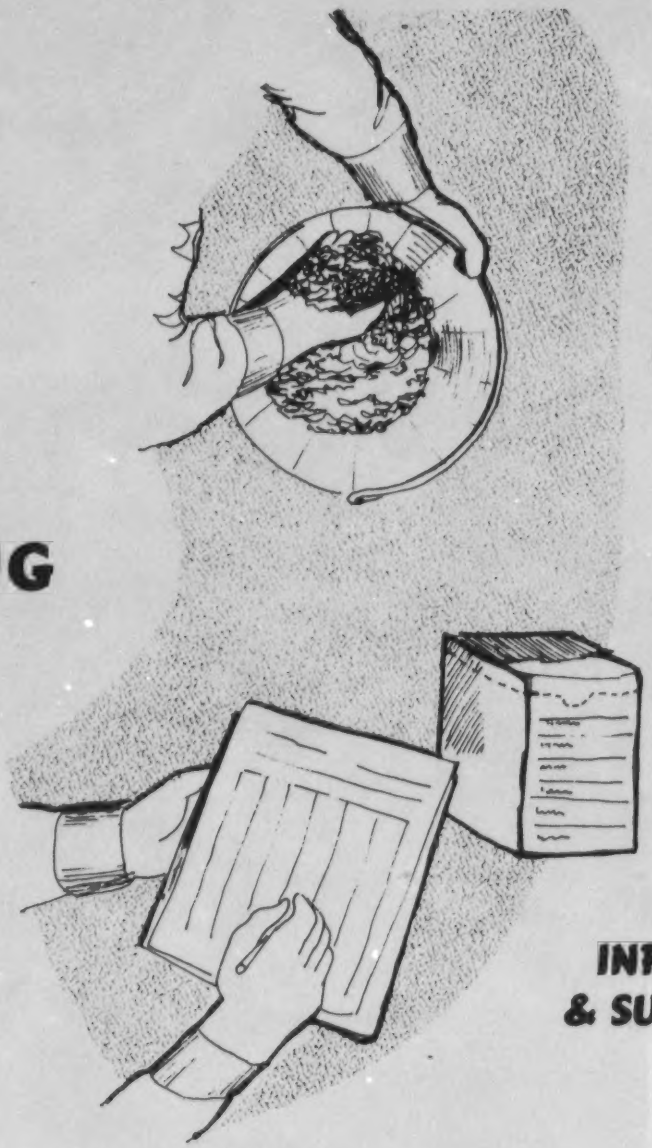
COLLECT A COMPOSITE SAMPLE FROM 10—15 PLACES

WITH A SPADE OR GARDEN TROWEL DIG A V—SHAPED HOLE, THEN TAKE A ½" SLICE FROM THE SMOOTH SIDE OF THE HOLE

F



SOIL SAMPLING



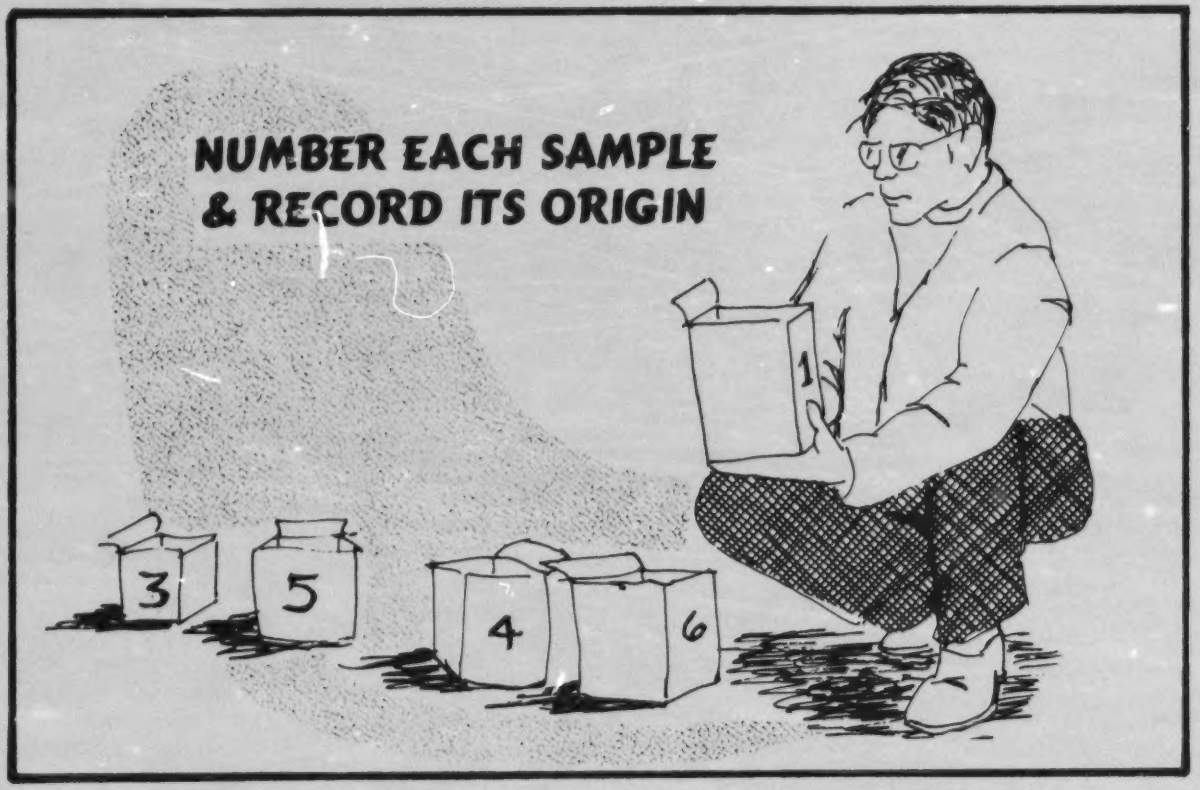
G

MIX SAMPLES IN A CLEAN CONTAINER

H

COMPLETE INFORMATION SHEET & SUBMIT WITH SAMPLE

SOIL SAMPLING



FOLLOW SOIL TEST RECOMMENDATIONS

SOIL SCIENCE

Unit C: Conserving Soils

Topic 1: Kinds of Erosion

*All terms underlined are included in the "Glossary of Terms."

I. What Is Erosion?

Erosion is the wearing away of the soil by forces of water and wind. The impact of the falling raindrop on bare soil is the major factor in starting the process of erosion. High winds blowing across unprotected soil causes severe losses of soil moisture and displaces soil particles. Soil erosion is present at higher elevations all over the United States, regardless of the amount of rainfall received.

II. Erosion in the United States

The United States has approximately 2,226 million acres of land of which 1,089 million acres were considered as farmland in 1973. Cropland and grassland pasture make up about 934 million acres of this total land area. The Soil Conservation Service has estimated that 282 million acres of this crop and grazing land have been ruined or heavily damaged by some form of erosion. They also estimate soil losses by erosion in our country at five and one-half billion tons annually. Losses from farm lands each year are estimated at three billion tons. This would be enough soil to fill a freight train that would reach around the earth 18 times. The equivalent of fifty 160-acre farms in topsoil is lost each day. Annual losses in dollars are estimated at nearly four billion, while the indirect effects of soil erosion cost additional hundreds of millions of dollars. Erosion contributes not only to soil losses, from flooding but also to damaging highways, railroads, and homes, and to causing loss of human lives.

III. How Does Erosion Take Place?

Nature has provided protection for soil in the form of vegetative cover. Vegetation protects the soil by breaking the force of raindrops, and holding the soil together by root system. Man, however, has upset the balance by removing vegetation and leaving the soil defenseless against the climatic forces of water and wind.

Transparency No. 1

The above transparency shows the relative degree of soil erosion in the United States. From this map, one can draw conclusions as to the degree of soil erosion in the State in which he lives. In Texas for example, a majority of the

State falls within the moderate erosion category. This would give some indication of the varying topography and rainfall across the State.

Level areas have little or no erosion while areas that are hilly suffer most from erosion. In areas that receive 30 inches or more of rainfall annually, most erosion is caused by water. When the rainfall is less than 20 inches, wind becomes the major eroding force. Both wind and water will cause erosion where the rainfall is between 20 and 30 inches. When rainfall exceeds the rate at which the soil can absorb the moisture, runoff and erosion will occur.

IV. Kinds of Erosion

As previously mentioned, soil erosion is caused by two primary sources, water and wind. Both of these kinds of erosion occur from either natural causes or man-made causes. Natural erosion or that form of erosion occurring without interference by man is called "geological erosion." There has always been geological erosion, and there always will be. It is the other form of erosion, "man-made," that results from man's endless efforts to subdue the land for his own personal gain without due regard for his posterity. Since man can be credited with the causes of much of the erosion that has reduced the productive capacity of the land, it is man that must bring about the changes for correcting these deficiencies.

A. Water Erosion

Soil is eroded by water in two stages, detachment and transportation. Falling raindrops on bare soil produces the first effect of soil detachment, while another force, running water, is responsible for the second stage, transportation.

Transparency No. 2

1. The effect of falling raindrops is known as "splash erosion." A single, beating one-inch rain may splash as much as one inch of soil depth by raindrop erosion. The dead weight of one inch of surface water on an acre is more than 100 tons. For an idea of the force involved in splash erosion, the weight of an acre of soil one inch deep is approximately 150 tons. Thus, 150 tons of soil an acre may be removed through splash erosion. Movement of soil by splash erosion is the primary cause of sheet erosion.

   Another effect of raindrop erosion on bare soil may be to seal the soil from infiltration during the first few minutes of a hard rain. Tests have revealed that water runoff on bare soil starts within one to four minutes of the beginning of the rainfall, and that from 95 to 98 percent of the rainfall is lost as runoff.

Transparency No. 3

Infiltration refers to the absorption of water into the soil.

When the rate of rainfall or intensity is greater than the ability of the soil to absorb water in the form of infiltration, runoff will occur. There is an important relationship between runoff, rainfall intensity, and infiltration rate. One way to state this example is the formula:

Runoff rate = Rainfall intensity — Infiltration rate

A high infiltration rate will occur only when the surface soil is in such physical condition as to provide channels through which water can move as rapidly as it falls on the surface. Water which cannot move into the soil is lost from the surface as runoff, often carrying soil with it.

This illustration depicts the principle of surface water runoff when the infiltration rate is not sufficient to handle the amount of rainfall.

Transparency No. 4

2. Runoff water is also a factor in soil erosion. As runoff water moves over the surface of the soil, the tendency is to flow along the paths of least resistance; therefore, some of it concentrates in low places to form channels. Continued flow in these channels develops minor rills, and eventually large gullies may be formed by the increasing volumes of runoff water.

   The common types of soil erosion shown on this transparency are sheet erosion, rill erosion, and gully erosion.

   a. "Sheet erosion" is the removal of soil in a uniform layer from an entire surface area. This type of erosion occurs continuously over periods of time, and the landowner may hardly be aware of its existence. Steep and moderately steep slopes will be affected most by sheet erosion. It will also occur whenever surface runoff water flows across unprotected land. A shallow surface topsoil over a dense impervious subsoil is especially vulnerable to this type of erosion.
   b. "Rill erosion" is a mild form of gully erosion. Small channels are made by running water in small streams over the surface of the soil. Rill erosion will appear as small fingers in a field or on an unprotected rangeland area. Damage may appear to be minor but if left unchecked, rill erosion can do a vast amount of damage.
   c. "Gully erosion" is the most noticeable form of erosion. It is an advanced stage of rill erosion and occurs when rills flow together into larger streams. Gullies will often being in slight depressions in fields. Tractor ruts, field roads, and livestock trails are logical places to look for gully erosion to begin.

Another type of water erosion that is sometimes overlooked is waterfall erosion. This type results from water flowing over dams, over terraces, at the head or along the sides of gullies, and other places. The great force that is generated by the falling water will cause severe damage if not controlled.

Transparency No. 5

Soil conservation measures for the prevention of soil losses and for the control of water erosion include both cropping and mechanical measures. Cropping practices recommended are an attempt to give as much protection to the ground surface as possible, while lands are being used, and also to increase the absorption of rainfall. Mechanical measures are designed to supplement the cropping program as well as control the movement of large quantities of rainfall on steeper slopes.

B. Wind Erosion

Wind erosion occurs mainly in the Great Plains section of the United States where rainfall ranges from 16 to 20 inches. The storms encountered by the settlers were "sand" storms," i.e., the wind carried large particles for short distances. In 1934, however, man encountered a new type of storm, the dust storm. The storm struck following a drought in the Great Plains and lifted an estimated 300 million tons of topsoil from the earth. The soil piled against fences and buildings; it covered crops and roads and drifted across the continent to the Atlantic coast. This storm was followed by many more which gave the mane of "dust bowl" to the Great Plains region of Kansas, Colorado, New Mexico, Oklahoma, and Texas.

In observing the evidence of wind erosion in very arid desert regions or along sandy sea shores, one would notice sand drifts or sand dunes resulting from geological wind erosion. Moving into the more productive areas, the type of wind erosion observed would be the result of poor land use. Sandy soils which have been overplowed, overgrazed, or overcut soon dig out without a protective cover and become subject to losses by wind erosion.

In areas subject to wind erosion where the original grass sod has been destroyed, the soil surface becomes dry, and these sandy soils are frequently shifted about by the wind. As the wind increases in velocity, deeper layers of soil are dried out and water, which helped to bind the soil particles together, is lost rapidly by evaporation. The result is a greater loss of the more fertile fine sand and silt particles that are carried away as "clouds of dust."

Control measures, which to a large extent have been effective, have been taken to reduce the hazards of wind erosion. These measures include:

Transparency No. 6

a. Strip Cropping

b. Prevention of Burning

c. Prevention of Grazing

d. Moisture Conservation

e. Emergency Cover Crops

f. Emergency Tillage Operations

g. Wind Break Tree Planting

h. Shelter Belt of Trees

Most wind erosion can be reclaimed by establishing adapted vegetation. Since the control of wind erosion is largely a community problem and one of keeping the ground covered or protected by vegetation, we will concern ourselves with water erosion in the following discussions.

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2. Soil, 1957 Yearbook of Agriculture, U. S. D. A., Washington, DC.

3. Vanderford, H. B., Managing Southern Soils, John Wiley & Sons, New York, NY, 1957.

4. Jacks, L. P. and J. Roland Hamilton, Basic Principles of Soil Science, Mississippi State University, State College, MS, 1965.

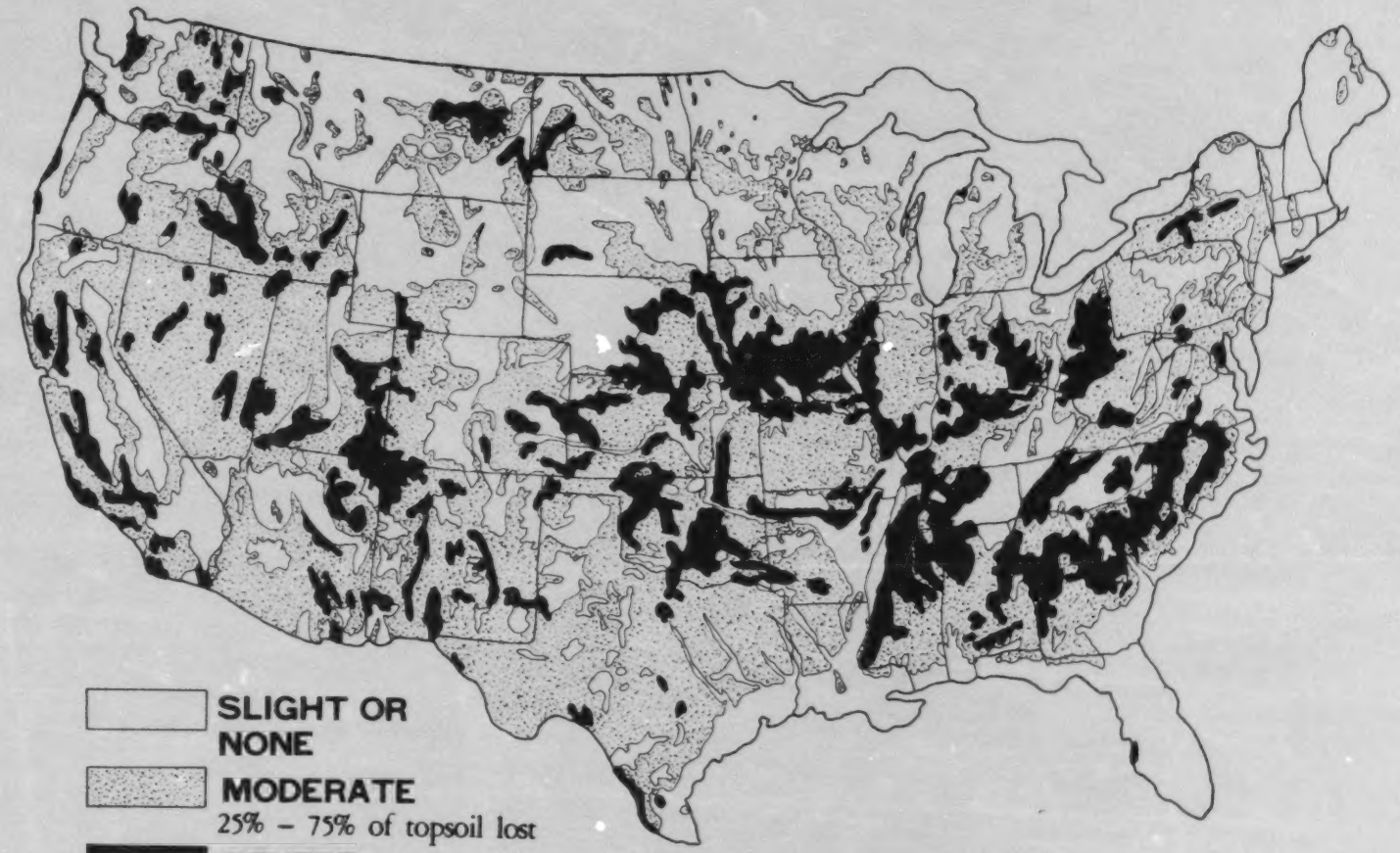
5. Donahue, Roy L., Our Soils and Their Management, Third Edition, The Interstate Printers and Publishers, Inc., Danville, IL, 1970.

6. Stallings, J. H., Soil Use and Improvements, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1957.

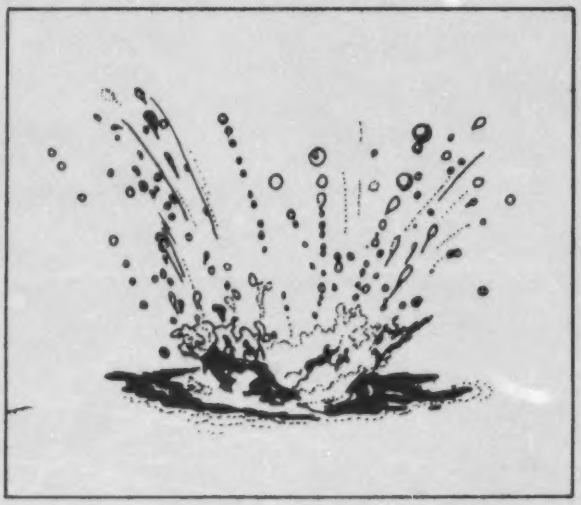
7. Donahue, Roy L., John C. Shickluna, and Lynn S. Robertson, Soils—An Introduction to Soils and Plant Growth, Third Edition, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971.

8. Knuti, Leo L., Milton Korpi, and J. C. Hide, Profitable Soil Management, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1962.

GENERALIZED SOIL EROSION MAP OF THE UNITED STATES

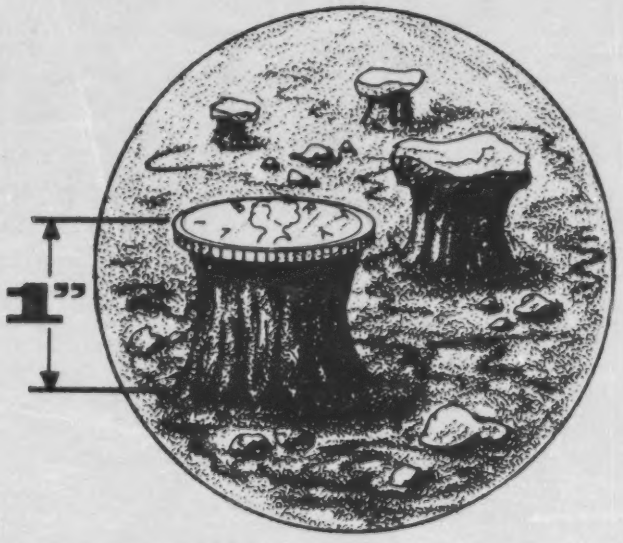


SOIL DETACHMENT BY RAINDROPS

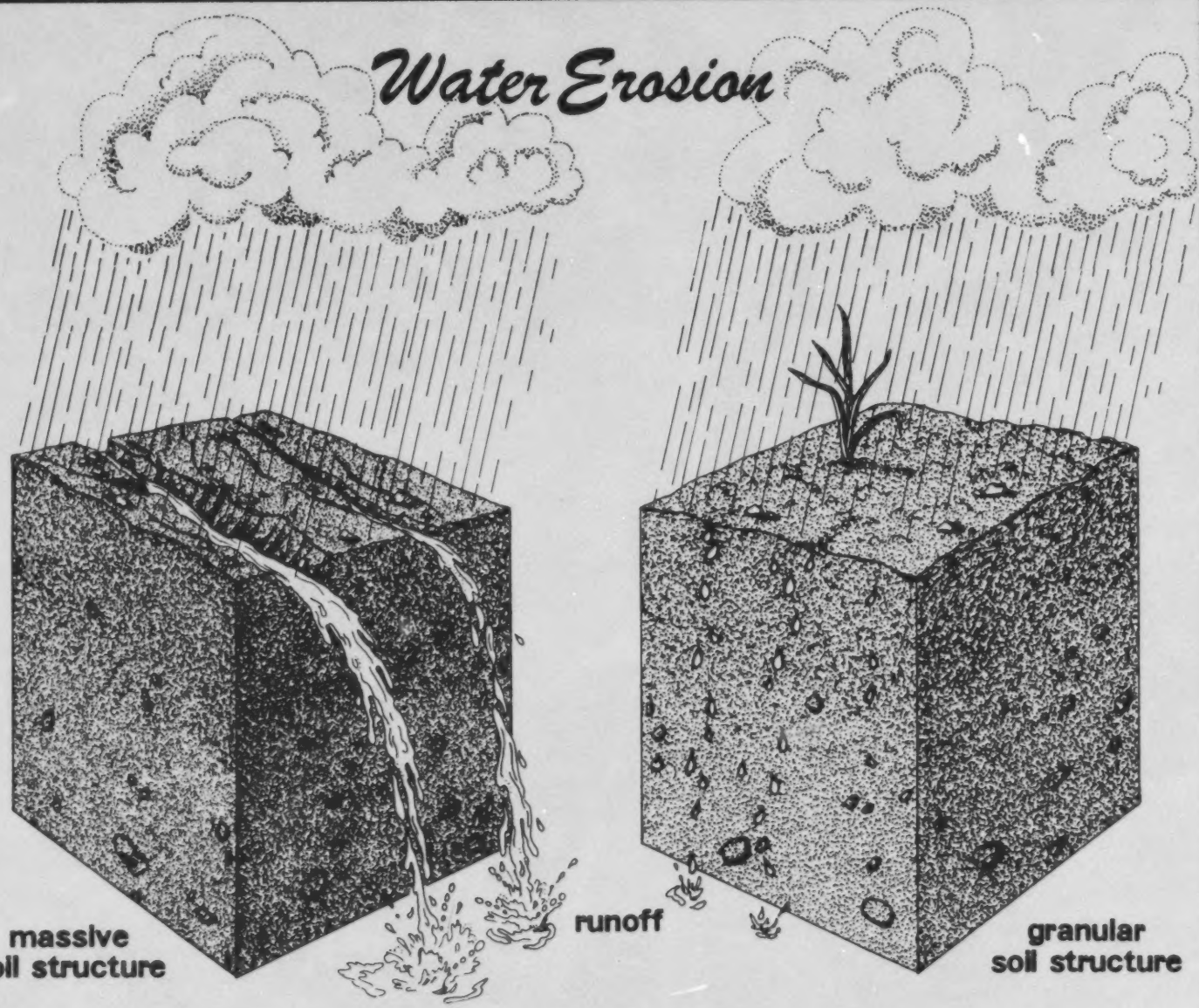


a raindrop may splash soil as far as 5 feet

a 1 inch rain may remove 1 inch of soil per acre (150 tons)



Water Erosion



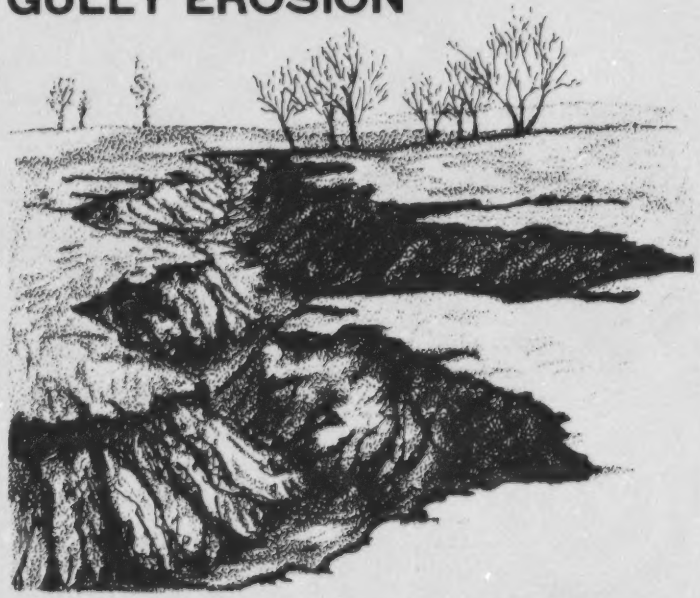
infiltration rate affects erosion due to runoff

EROSION CAUSED BY RUNNING WATER

SHEET EROSION

RILL EROSION

GULLY EROSION



WATER EROSION CONTROLS

MECHANICAL

TERRACING
DIVERSIONS
GRASSED WATERWAYS
LAND DRAINAGE
LAND PREPARATION (SHAPING, SMOOTHING, LEVELING)
CONSTRUCTION OF PONDS & DAMS

CROPPING

SUBSOILING OR CHISELING
CONTOUR FURROWING
CONTOUR LISTING
STUBBLE MULCHING
STRIP CROPPING

WIND EROSION . . . . .

A. STRIP CROPPING

B. PREVENTION OF BURNING

C. PREVENTION OF GRAZING

D. MOISTURE CONSERVATION

E. EMERGENCY COVER CROPS

F. EMERGENCY TILLAGE OPERATIONS

G. WINDBREAK TREE PLANTING

H. SHELTER BELT OF TREES

. . . . . CONTROL PRACTICES

SOIL SCIENCE

Unit C: Conserving Soils

Topic 2: Factors Influencing Soil Erosion

*All terms underlined are included in the "Glossary of Terms."

I. Soil Erosion

Farmers, like many people of other occupations, many times are creatures of routine. The farmers who have been farming flat land in straight rows with little erosion will probably continue cultivating in this method. The hazardous thing about this practice is that when they take over farms on sloping land, the flat land practice will still be followed. It is true that not all farmers have to be reminded of the importance of the use of soil erosion practices. Farmers of northern European descent, for example, use wise conservation methods from more or less habit and custom.

From the earliest of the state and federal laws concerning soil and water activities, many people have been placing the blame for soil erosion on landowners. In 1887, Greer County, Texas, was organized. One of the laws affecting this county was that each family was permitted to own four sections of land. However, in 1896, due to an incorrect land survey, the United States Supreme Court ruled this county to be part of the Territory of Oklahoma. Because the land was a part of the Territory of Oklahoma, it became land under the Federal Homestead Act. This act limited each family to ownership of one-fourth section of land or 160 acres.

This part of the country, known as Greer County, has approximately 25 inches of precipitation per year. Due to the limited amount of rainfall, beef cattle raising was about the only type of farming that was worthwhile. It took at least 20 acres of grass per animal. If we figure this over the entire farm of the family, which was 160 acres, we find that only eight animals could properly be supported by the land. Even in the latter 1800's, this was not a number sufficient to supply income to feed, clothe, and educate the family.

Consequently, the limitation of the number of acres per family led to extreme overgrazing. Due to the overgrazing, erosion resulted. From this time until the present, many people have blamed landowners resembling these as causing erosion. However, let's go further into the problem and see if the landowners and original land laws are really the causes of erosion.

II. Factors Influencing Soil Erosion

On any given piece of land there are a number of factors that affect erosion. They are listed as follows:

The Nature of the Soil
Climate
Vegetative Cover
Slope and Horizontal Length
The Management of the Soil

A. The Nature of the Soil

1. Texture—Soils with high clay content do not erode as easily as soils that are sandy or silty. The clay particles tend to stick together and, therefore, have a stronger bond than do other types of soil. Silty soil is loose and tends to erode easily. Sandy and loamy soils will absorb water and reduce runoff but will wash in heavy rains.
2. Structure—Good structure will hold the soil together giving the water a chance to sink in. Before particles are washed away they must be detached. Crumb and granular structure are the most desirable since they allow moisture to move through the clusters as aggregates of soil particles, thus reducing runoff and increasing the amount of moisture to the plants.
3. Depth of the Soil—Deep soils will take up much rain water if they are permeable. This will help to reduce runoff since the more that is absorbed the less is available for runoff. Soils with hardpan layers near the surface will not absorb much water and are more susceptible to erosion.
4. The Organic Matter Content—Soils with high organic matter content have increased absorptive capacity. They also increase plant growth which provides protection from the elements.

B. Climate

1. Climate is the combined effect of wind, temperature, and rainfall. Rainfall is considered the primary eroding force in Texas. For over 7,000 years it was thought that only running water caused erosion. In the last few years, however, raindrop splash has been recognized as a major factor in erosion. Raindrop splash can be defined as the force of impact of raindrops upon the soil. The tremendous force of raindrop splash can be observed by noticing how dirt is splashed upon a house during a rain. Some of the ways that raindrop splash affects the soil are:
   a. Gradually moves the finer materials from the soil and leaves less fertile, coarser sands, and gravels.
   b. Detaches soil and breaks down soil structure. Such finer particles are more easily transported, and erosion is thus accelerated. This means that raindrop splash is causing a gradual downhill movement on a hillside.
   c. Tends to seal the surface by causing puddling of the soil. Infiltration is reduced and produces higher surface runoff.
2. The higher runoff, in turn, is able to transport more material. Thus, a hard-beating rain brings about a vicious cycle, multiplying erosion in many

ways. Water erosion, is a product of both splash erosion and erosion caused by water flowing over the surface.

C. Vegetative Cover

1. Soil that is covered is protected from the forces of raindrop splash and running water. The good farmer recognizes the importance of vegetative cover in controlling erosion. The more cover the land has, the less erosion will take place. Vegetation will hold the soil particles together, cushion the impact of raindrops, and increase infiltration, all of which will decrease erosion.
2. The following table from a Missouri experiment station bulletin shows the effect of cover or cropping systems on the rates of erosion and runoff:

Cropping System	Average Annual Rate of Soil Loss in Tons Per Acre	% of Total Rainfall Running Off the Land
Bare, cultivated, no crop	41.0	30
Continuous corn	19.7	29
Continuous wheat	10.1	23
Rotation: corn, wheat, clover	2.7	14
Continuous bluegrass	0.3	12

D. Slope and Horizontal Length

1. The steepness and horizontal length of land will have a great effect on erosion. As water moves down a slope, it increases in velocity and carrying capacity. For example, doubling the percent slope will increase soil loss 2.5 times. Doubling the length of slope will increase soil loss 1.4 times.
2. The slope should always be considered in determining the use of land. Cultivation of steep land should always be avoided.
3. Slopes can be classified as follows:
   a. Nearly level..... Less than 1 foot fall in each 100 feet
   b. Gentle sloping..... 1 to 3 feet fall in each 100 feet
   c. Moderately sloping.... 3 to 5 feet fall in each 100 feet
   d. Strongly sloping..... 5 to 8 feet fall in each 100 feet
   e. Steep..... 8 to 12 feet fall in each 100 feet
   f. Very steep..... Above 12 feet fall in each 100 feet

E. Management of the Soil

The way the soil has been managed will determine, to a large degree, the amount of erosion. Bad management practices will destroy good land. The good farmer recognizes erosion as a problem and works to overcome it. In the following topics, we will study some of the practices that will help to control erosion.

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3. Knuti, Leo L , Milton Korpi, and J. C. Hide, Profitable Soil Management, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1962.

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SOIL SCIENCE

Unit C: Conserving Soils

Topic 3: Erosion Control Measures

*All terms underlined are included in the "Glossary of Terms."

I. Soil Erosion Has Been a Problem Since the Beginning of Time

The large number of starving people around the world indicates that man has failed to properly care for our greatest natural resource—top soil. The users of soil must take necessary steps to understand the mistakes that have been made in the past. From these mistakes man can hopefully implement measures that will help control soil loss.

Going back to early civilizations in the United States, we may visualize some of the mistakes that were made concerning soil erosion. This was a time of plenty—rich, deep soil; timber; grasslands; etc. The early settlers and the people that followed began using these natural resources as though they would last forever. The grasslands were overgrazed and trees were cut from the hills. The good, rich soil was an invitation to plant more and more cultivated crops. The timber was removed to build needed homes and cities. The population of the nation was growing by leaps and bounds and more food was needed.

Schools sprang up throughout the land and man was becoming educated. However, one thing that man didn't understand was the balance of nature's forces. Due to the lack of knowledge of nature's forces, an extreme amount of top soil was needlessly lost.

From the time of the early settlers, the problem of soil erosion was to be felt by each generation. Even though the seriousness of soil erosion was beginning to be recognized by state and national leaders, a national movement to control erosion was not started until 1933, when the Soil Erosion Service was established. In 1935, the name of the Soil Erosion Service was changed to the Soil Conservation Service. At that time, the Soil Conservation Service, as a federal agency, offered direct assistance to landowners in erosion control programs. Then in 1937, the first Soil Conservation Districts were organized and assistance was offered to landowners in a more localized manner.

Today, all states, including Puerto Rico and the Virgin Islands, have passed laws authorizing the organization of some 3,026 Soil Conservation Districts, comprising more than one billion acres of land. Approximately 99 percent of the farms and ranches in the United States are cooperators in soil conservation programs.

II. What Are Some Management Practices that Will Control Erosion?

There are many methods that are used to control erosion. The best methods for any farm can be determined only through study of the soils found on the farm and the particular situation. Since soils differ from field to field, each field is a separate problem in erosion control. As soon as the soils are identified on a farm, the following should be considered:

Transparency No. 1

Use of the Land	Fertilizer and Lime
Water Disposal System	Control of Gullies
Cover Crop	Erosion Control Pla

These management practices will be discussed more in detail in the following paragraphs.

A. Efficient Use of the Land

Efficient use of the land should be the primary consideration of any good farmer. By efficient use is meant the use of land in such a way that maximum income and satisfaction is realized with minimum damage to the land. For example, crops planted on steep land may result in more loss due to damage to the land than is realized from the added income. The farmer should try to use the land in such a way that he will realize income while at the same time protect the land.

Some of the factors to be considered in making the decision of which crop to plant are listed below:

Transparency No. 2

1. Nature of the Soil
   a. Steepness of the land
   b. Will erosion be a problem to control?
   c. Is the crop suited to the soil conditions?
2. What is the potential income that can be provided by the crop?
3. What are the personal preferences of the landowner under existing soil conditions?
4. What effect will the production of this crop have on the land?
   a. Removal of soil nutrients
   b. Continuous use of this crop on soil conditions
5. How will the crop fit into the present crop rotation system?

B. Water Disposal System

In high rainfall areas, more rain is received than the soil can take up. Since the excess water will run off the land, steps should be taken to insure that water runs off with a minimum of soil washing. Some of the steps in controlling water runoff are:

Transparency No. 3

1. Terracing—A terrace is the structure designed to slow down running water and control erosion on sloping land. When planning terraces one should consider their width, height, length, outlets, and direction. Terraces will usually empty into a grass waterway or concrete flume to prevent gullying at the point of the outlet. They are built so that there will be only a slight fall between them to slow down running water.
2. Strip Cropping—Strip cropping is the practice of planting crops in narrow strips, in which close growing crops are grown next to cultivated crops. The principle is for the meadow crop to slow down the water moving down the slope. These strips are plowed on the contour. The width of the strip depends on the percent and length of the slope and the soil type.
3. Crop Rotation—The rotation of a field from a row crop to a sod-type crop retards erosion by increasing the amount of organic matter in the soil and by providing cover for the surface on years when the close growing crop is grown.

Transparency No. 4

4. Water Outlets—Water outlet refers to the ditch which carries the excess water off the farm. In recent years, grass waterways have come into importance as a water outlet method. Other outlets include metal culverts and concrete ditches. Attention should be given to the major water outlets to insure that no gullies form.
5. Diversion Ditches or Levees—Diversion ditches will help prevent erosion by diverting water around a field rather than across. Diversion ditches are around the upper end of a field but care must be taken to assure that they do not cause damage by cutting off the water course itself or forming gullies where the water is released.

Transparency No. 5

6. Contour Plowing—Contour plowing is the most fundamental step toward erosion control on cultivated land. It reduces runoff by temporarily holding back the water and allowing more time for penetration. In many cases, where the slope is gentle, proper row direction may be the only erosion control method needed.
   a. Step 1—The first operation in contour plowing is to establish a contour guide line that runs across the field or around the slope at a constant level. Then the remainder of the field can be plowed using this as a guide.
   b. Step 2—Continue plowing but leave a turn strip at the lower part of the field. Plow around the contour guideline, lifting the plow from the ground when crossing the waterway.
   c. Step 3—Continue from step 2 by plowing out the area, leaving the turn-strips in grass if desired.

C. Cover Crops

Land which is not suitable for cultivated crops due to soils, slopes, or erosion may be critical areas which should be covered with vegetation. The kind of vegetation will depend on soils and the need which the farmer needs to make of such plants. Deeprooted legumes such as lespedeza and kudzu provide good cover and grazing. Trees can sometimes be used as a cover crop. Cover crops will not only protect poor areas from erosion, but also provide a source of additional income.

D. Use of Fertilizer and Lime

While fertilizer and lime do not have a direct effect on erosion, they do have a great indirect effect. Soils that are fertile will cover faster and more uniformly than unfertile soils. Cover crops need fertilizer to cover properly and protect against erosion. This is also true of cultivated crops. The quicker their root systems expand to bond the soil together, the less likely the chances for erosion. The farmer should certainly consider the fertility requirements of his soil when planning an erosion control system.

E. Control of Gullies

Since gullies are formed by water being concentrated into a central area, the first step in controlling them is to divert the water from that area. This can be done by using a terrace or diversion ditch.

The next step is to provide protective vegetation for the gully. Brush dams are a good method to hold the soil and water until it is possible to start plants. Kudzu is a good plant to stop gullies where the soil is suitable. Trees can be used to provide an effective control for deep gullies, but time should be provided to get started. Grasses provide good cover to stop the washout in a gully. Native grasses are best suited to gully plantings in most areas. Once cover is established, the gully can be used for grazing or other purposes.

When a gully is planted, it may be necessary to do some bank sloping, particularly if the area is steep. Usually a satisfactory growth can be established without extensive sloping. In some areas, monetary assistance on a fund matching basis can be obtained through the local A.S.C.S. office for gully sloping programs carried out by the landowner.

F. Erosion Control Plan

Every farm should have some sort of soil erosion control plan. Assistance can be obtained from the local Soil Conservation Service (SCS) office in making a conservation plan to protect the land against erosion. A system of disposing of excess water is necessary on all farms and ranches on which excessive runoff occurs. The natural processes of erosion have created natural drainage patterns. The runoff from and within fields is collected in these natural drainageways and carried to main-stream channels. A conservation plan provides for using natural waterways to carry runoff and for shaping land where necessary to make water courses large enough to carry runoff at nonerosive velocities. This plan also provides for the maintenance of channels in grass.

When planning for erosion control, there are many factors that one must consider. The following list will provide a guide to some of the considerations:

Transparency No. 6

1. The Effect of Erosion on the Farm
   a. Effect on the value
   b. Effect on the production now and in the future
2. The Effect of Erosion on the Community
   a. What is the farm's value to the community?
   b. How other farms are faced with the same problem
3. What type of erosion control practice will you use?
   a. What kind of land do you have?
   b. What control practices are best suited for your land?
4. Cost of the Erosion Control Practices
   a. Can you afford them?
   b. Can you afford not to use them?
5. What are some of the benefits you will realize from erosion control?
6. How will the erosion control plan be implemented on the farm or ranch?

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MANAGEMENT PRACTICES USED IN CONTROLLING EROSION

A. EFFICIENT USE OF THE LAND

B. WATER DISPOSAL SYSTEM

C. COVER CROP

D. FERTILIZER & LIME

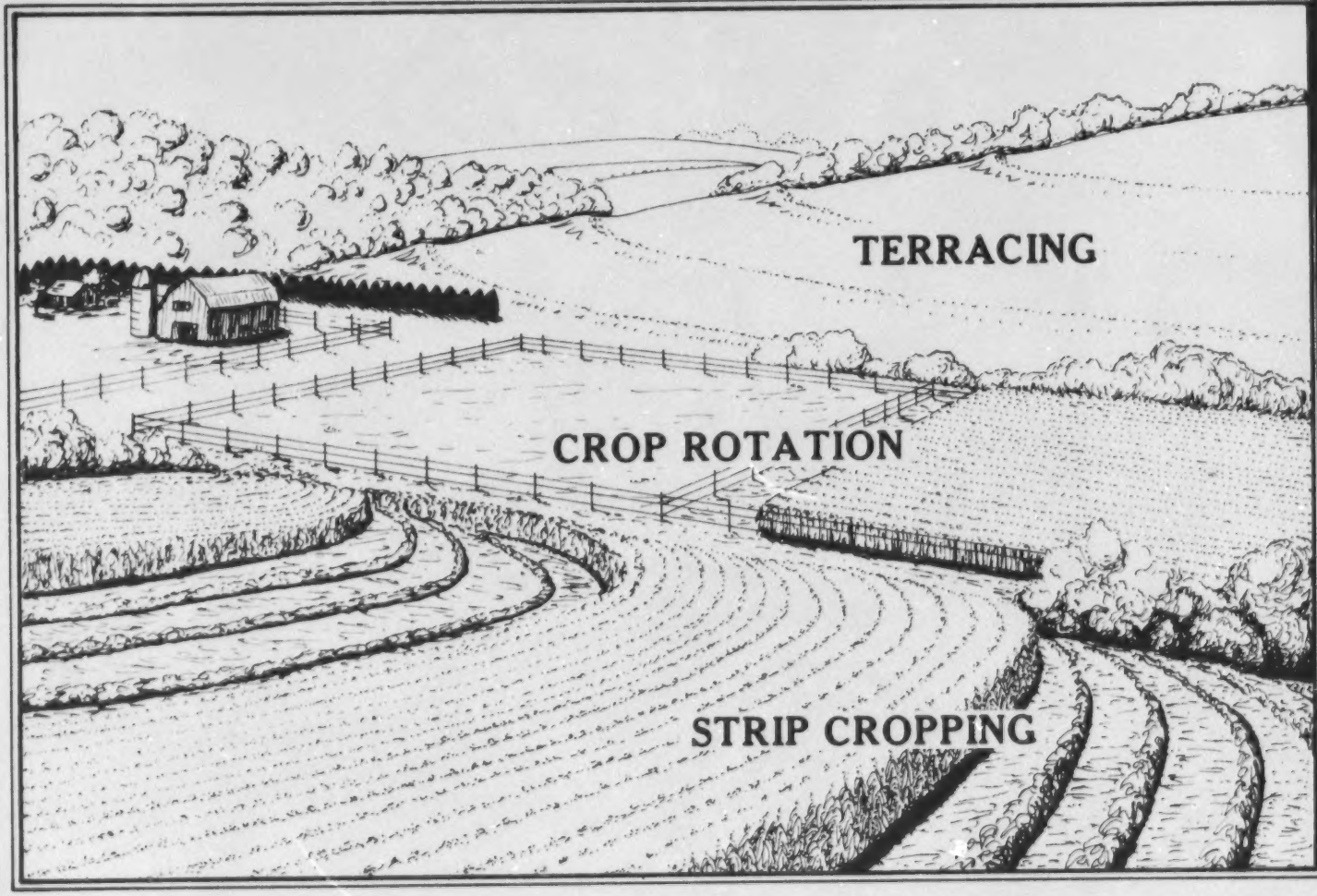
E. CONTROL OF GULLIES

F. EROSION CONTROL PLAN

FACTORS AFFECTING CROP SELECTION

1. NATURE OF THE SOIL
   - A. SLOPE OF THE LAND
   - B. EROSION CONTROL
   - C. SOIL CONDITIONS
2. POTENTIAL INCOME
3. PERSONAL PREFERENCES
4. EFFECT ON LAND
   - A. SOIL FERTILITY
   - B. CONTINUOUS USE OF CROP
5. SUITABILITY IN CROP ROTATION SYSTEM

MANAGEMENT PRACTICES USED IN CONTROLLING EROSION



V. A. I

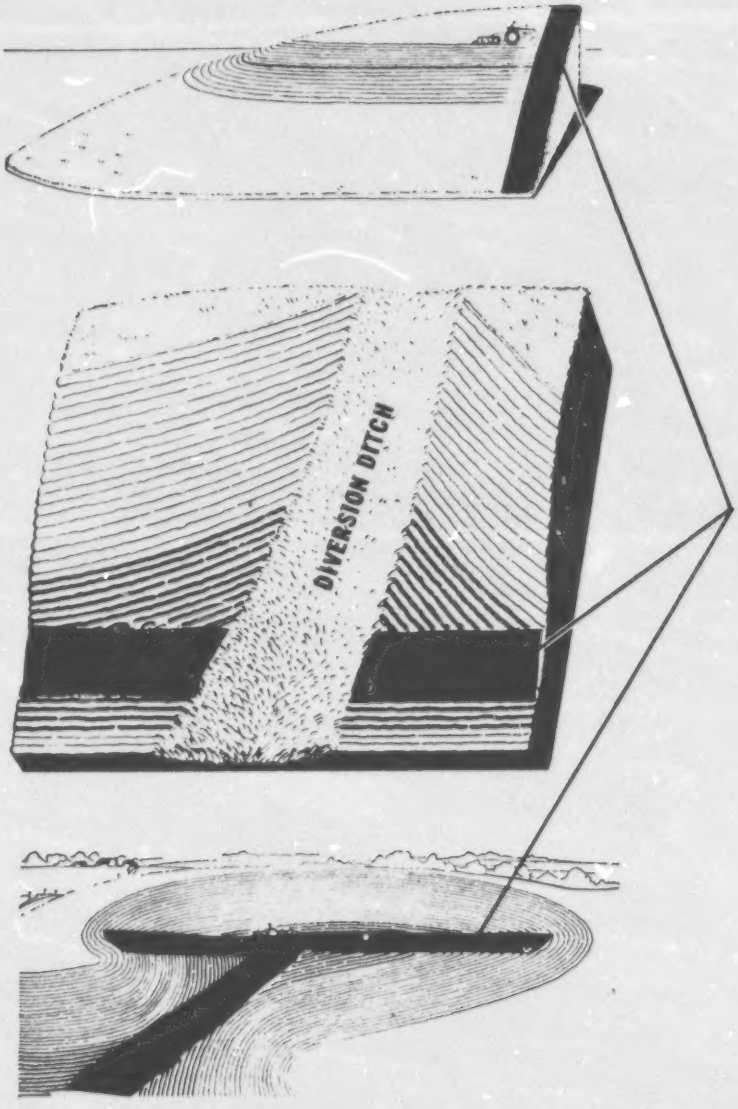
III-C-3
No. 3

WATER OUTLETS

MANAGEMENT PRACTICES USED IN CONTROLLING EROSION

DIVERSION
DITCHES OR LEVEES

MANAGEMENT PRACTICES USED IN CONTROLLING EROSION



CONTOUR FARMING

Considerations For Planning Erosion Control

A. EFFECT ON THE FARM

B. EFFECT ON THE COMMUNITY

C. TYPES OF PRACTICES

D. COST

E. BENEFITS

F. IMPLEMENTATION

SOIL SCIENCE

Unit D: Conserving and Controlling Soil Water

Topic 1: Importance, Kinds, and Losses of Soil Water

*All terms underlined are included in the "Glossary of Terms."

I. What Is Soil Water?

Soil water can be thought of as the moisture in the soil. Soil water plays an extremely important part in the growth of plants. Since all soils have some degree of moisture, the amount that is available for plant growth becomes of primary importance. For the farmer, the conserving of soil water is an attempt to prevent drought. We know that plants take moisture from the soil with their roots and transport it to the leaves which pass it on to the atmosphere by transpiration. Drought can be said to exist any time that the demand for water from the leaves is greater than the supply from the roots. Too little moisture will prevent plants from utilizing their full potential. Some of the ways soil water serves plants are listed below:

Transparency No. 1

Water is essential for plant growth.
Water is necessary for soil formation.
Water makes nutrients available.
Water influences the physical condition of soil.

A. Water Is Essential for Plant Growth
Water is a necessary constituent of plant protoplasm, making up 85 to 90 percent of the fresh weight of actively growing plants. It is essential for maintaining the proper form and position of leaves and new plant growth. Plants require a supply of water from germination to maturity. When the water supply is cut off, green plants will wilt and die within a short time. The point at which they wilt is known as the wilting point. Even trees contain more than 50 percent water.

B. Water Is Necessary for Soil Formation
Water is a necessary ingredient in soil formation. It aids in the weathering of rocks and breaking down of minerals that make up a large portion of the soil. The formation of a soil profile is also largely dependent upon water.

C. Water Makes Nutrients Availabie

In order for plants to function properly, they must have a food source. Water dissolves nutrients and makes them available to the plant in solution form. The roots are better able to take in the nutrients in solution. Fertilizer and lime are dependent upon water to dissolve them so that they will be available to the plant; without moisture, they have little effect.

Although plants absorb some water from rain and dew, most of the water used by plants comes from water held by the soil.

D. The Physical Condition of the Soil Is Influenced by Water

A cultivated loam soil in good physical condition for plant growth is comprised of approximately half solids (sand, silt, clay, and organic matter) and half pore spaces. The pore spaces are occupied by half air and half water; and only half of the soil water is available to plants. The other half of the soil water is held in thin films and in gaseous form and plants cannot absorb it.

The farmer is often interested in soil water as it affects the soil in preparing a seedbed. Heavy soils, such as clay, are sticky and tough when the moisture is high. When it is low, they are hard and do not work well. Farmers often use the process of wetting and drying on heavy soils so that they may be worked.

II. How Do Soils Get Moisture?

Rainfall is the primary source of soil moisture.

(Use Transparency III-D-3, No. 4.)

This transparency shows the average rainfall for the different areas in Texas. There is a gradual decrease from east to west. Although average rainfall figures are deceptive, they do give the farmer a basis for planning. For example, in the western regions, the farmer must plan for irrigation while in the eastern portion of the state there is ample moisture without irrigation.

III. Kinds of Soil Water

Transparency No. 2

There are three kinds of soil water that we will be concerned with. These are capillary water, hygroscopic water, and gravitational water.

A. Capillary water—Capillary water is the water that adheres to the soil particles. This type of water will move in the soil by "capillary attraction," from one soil particle to another. The finer the soil, the more surface is exposed for capillary water to adhere to. The capillary water, therefore, will be higher in fine soils, such as clay, than in coarse soils, such as sand. When the amount of capillary water is high, it is removed from the soil easily by the plants, but as more is removed, it becomes harder for the plant to get

the moisture it needs. When the amount of moisture is decreased below the level needed by the plant, wilting occurs. Capillary is by far the most important soil water for plant growth. Capillary water will evaporate during periods of drought.

B. Hygroscopic water is held tightly by the soil particle. It is not available for plant growth. Even in very dry soils, some hygroscopic water is present since complete removal requires baking the soil in an oven for long periods of time.

C. Gravitational water is the free or excess water in the soil. It can be moved by the force of gravity. Fields with poor natural drainage may contain gravitational water. This type of water is available to the plants, but causes unfavorable conditions to occur. When the soil is waterlogged, plant roots do not function normally because they cannot get enough air to do so. Rice is one of the few crops that will grow when gravitational water is present in large quantities. Drainage is sometimes necessary to remove gravitational water.

IV. Measuring Soil Moisture

Regular inspection of soil moisture conditions can provide valuable information about the amount of soil moisture in the soil. It can be used as a basis for determining when to irrigate or as a basis for other management decisions. For most crops, irrigation should begin when the soil moisture drops below 50 percent of the available soil moisture.

A. A practical method of estimating available soil moisture is to squeeze a small amount of soil to form a ball. Table 1, Page 7 will give a description of the feel and appearance of different textured soils containing various moisture percentages.

Estimating soil moisture by feel and appearance is not a precise measuring method. However, this method is effective if results are observed carefully. For example, suppose you have a sandy clay loam soil which you estimate contains an average of 50 percent available moisture in the root zone depth of three feet. If you estimate the soil should hold 2.0 inches of available moisture per foot of soil, or a total of 6.0 inches in the root zone at field capacity, the remaining available moisture is estimated at 50 percent. (Refer to Table I, Page 7.)

Depth of water penetration into the soil can be determined by using a soil probe, sharpshooter, shovel or posthole digger. By using this method, you can approximate the amount of actual moisture available to the plant.

Transparency No. 3

B. Other more precise methods of measuring soil moisture include:

1. First is the gravimetric method. It consists of obtaining a moist soil sample, placing it in an oven at 105° C until it is completely dry, and then determining the percentage of moisture. The calculation would be done as follows:

$$\text{Percent moisture} = \frac{\text{Loss in Weight}}{\text{Oven-dry Weight}} \times 100$$

2. Second are methods that depend upon measuring the equilibrium tension of soil moisture using a porous clay cup (tensiometer) filled with water. By this method, a vacuum gauge is attached to the cup, and as the soil dries out, water moves through the porous cup, setting up a negative tension or vacuum. These tension readings can then be calibrated to interpret the percentage of moisture.
3. Third are methods that are based on changes in electrical conductivity between two electrodes in relation to changes in soil moisture. The electrodes fixed inside of blocks of gypsum, nylon, fiberglass, or other porous material are buried at a set distance apart in the soil. Wires from each block extend to the surface of the soil and are connected to a Bouyoucos bridge instrument which gives a conductivity reading that can be calibrated to percentage of soil moisture.

V. What Are the Ways Soils Lose Water?

There are many ways that soils lose water. Some of the most important ways are runoff, evaporation, transpiration, and percolation.

Transparency No. 4

A. Runoff—The amount of rainfall that enters the soil is important to the farmer. Since we are limited in our ability to modify or control rainfall, we must take it as it comes. We can, however, control infiltration and runoff to some extent. When runoff occurs, rainfall has exceeded in intensity and volume that amount which the vegetation and soil will absorb. Some of the factors that will affect runoff are: slope, nature of the soil, depth and condition of the soil, and the season.

The nature of the soil plays a major role in infiltration of water into the soil. The size of the pores largely depends on the size of the particles that make up the soil.

There are three ways a farmer can help to control runoff.

1. By altering the surface soil, he can increase infiltration rates.
2. He can slow down the flow of water, giving the soil more time to absorb moisture.
3. He can plan his cropping system to better utilize the seasonal rainfall in his area.

B. Evaporation—The loss of soil moisture to the air. It is the process of transforming the liquid water to a vapor. For evaporation to occur, there must be a supply of energy and a mechanism of transfer.

The sun is the source of energy which transforms water from a liquid to a vapor. Plants absorb some of the energy radiated by the sun. Some of the energy goes toward heating the air, heating the soil, and evaporating water. If there is little moisture available for evaporation, most of the radiant energy of the sun will go toward heating the air. If there is moisture available for evaporation, the energy will go toward heating the soil and evaporating the moisture.

The second factor that must be present is a mechanism of transfer. The water first is transported from the soil reservoir to the surface of through the crop to the leaf surfaces. The water vapor is then transported from the surfaces to the atmosphere.

Evaporation is also influenced by the wind and relative humidity in the air. In areas where periods of dry weather are accompanied by strong winds, the soil tends to dry quickly. Under these conditions surface moisture is evaporated almost as fast as the soil water moves to the surface. This, in effect, thins the water films throughout the soil mass.

C. Transpiration is the omission or loss of a watery vapor from plant parts. The same condition is necessary for transpiration as is necessary for evaporation. As the soil loses water, the amount of plant transpiration decreases. The rate at which a soil will dry depends on the amount of water in the soil, the ability of the soil to give up the water, and how widely the plant roots are distributed in the soil.

Over 99 percent of water absorbed by plants is given off by transpiration. The amount of water that plants must absorb to produce a pound of dry matter varies from 250 to 1,000 pounds. This is referred to as the transpiration ratio.

In Colorado experiments, the transpiration ratio under dry climate conditions was observed to be as follows:

Crop	(*Pounds of water for one pound of dry matter)
Millet and sorghum	300 lbs.
Corn	350 lbs.
Wheat	500 lbs.
Potatoes	630 lbs.
Clover	800 lbs.
Alfalfa	860 lbs.

*These ratios will vary from year to year and from area to area.

D. Percolation is the movement of water down through the soil. Water will move through the soil by the force of gravity until it reaches an impervious layer that will not allow it to go farther. The water will collect at this layer and supply wells and springs. Percolating waters are the only source of recharge of water for springs and wells.

The conditions which will affect percolation are texture, structure, and hard pans (compacted layers). Soils with high levels of sand and gravel will have rapid percolation, while clay soils will allow very little percolation through them. These soils may hold water at or near the surface and are sometimes called "waterlogged."

Percolation is not necessarily bad for the soil when it occurs in limited quantity. Excessive percolation will cause a loss of both water and nutrients from the soil which will hinder plant growth. Percolation should not be prevented, but controlled by farmers.

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1. Knuti, Leo L., Milton Korpi, and J. C. Hide, Profitable Soil Management, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1962.

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4. Vanderford, H. B., Managing Southern Soils, John Wiley and Sons, Inc., New York, NY, 1957.

TABLE I: ESTIMATING SOIL MOISTURE BY FEEL AND APPEARANCE

Degree of Moisture	% Useful Soil Moisture Remaining	Feel or Appearance of Soils			
		Coarse	Moderately Coarse	Medium	Fine
Dry	0	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery, dry, sometimes slightly crusted, but easily breaks down into powdery condition.	Hard, baked, cracked; sometimes has loose crumbs on surface.
Low	25 to wilting percentage	Soil appears to be dry; will not form ball with pressure.*	Soil appears to be dry; will not form ball. *	Somewhat crumbly, but will hold together from pressure. *	Somewhat pliable; will ball under pressure. *
Fair	25 to 50	Soil can be formed slightly when pressed and appears to have more moisture than indicated above.	Tends to ball under pressure but seldom will hold together.	Forms ball, somewhat plastic; will sometimes slick slightly with pressure.	Forms ball; some clays will ribbon out between thumb and forefinger.
Good	50 to 75	Tends to stick together slightly; sometimes forms very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms ball and is very pliable, slicks readily if relatively high in clay.	Easily ribbons out between fingers, has slick feeling.
Excellent	75 to field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as coarse.	Same as coarse.	Same as coarse.
Too wet	Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water form on surface.

*Ball is formed by squeezing a small amount of soil very firmly in your hand.

FUNCTIONS OF SOIL WATER IN PLANTS

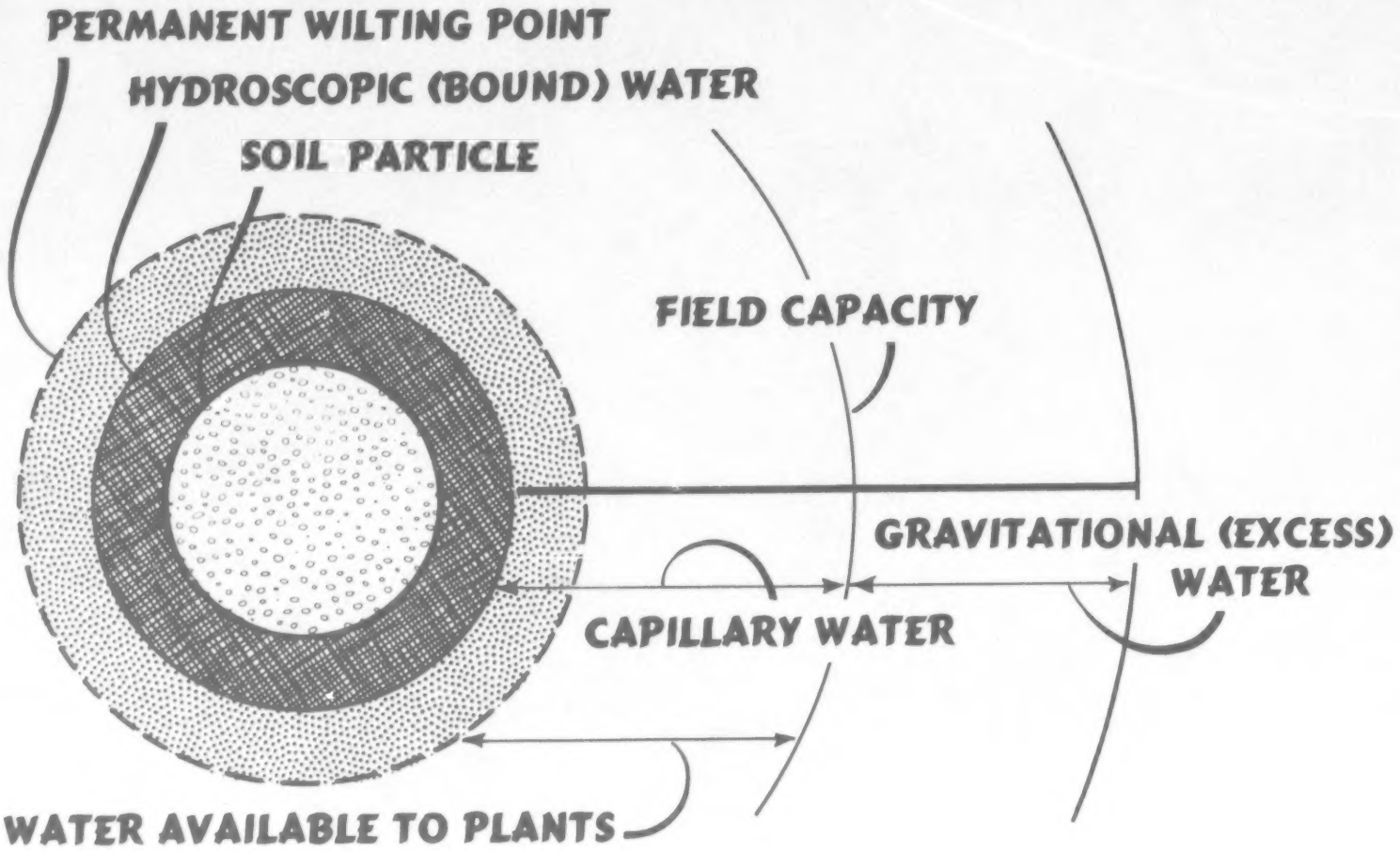
A. ESSENTIAL FOR PLANT GROWTH

B. NECESSARY FOR SOIL FORMATION

C. MAKES NUTRIENTS AVAILABLE

D. INFLUENCES THE PHYSICAL CONDITION OF SOIL

CLASSIFICATION OF SOIL WATERS



MECHANICAL METHODS OF MEASURING SOIL MOISTURE

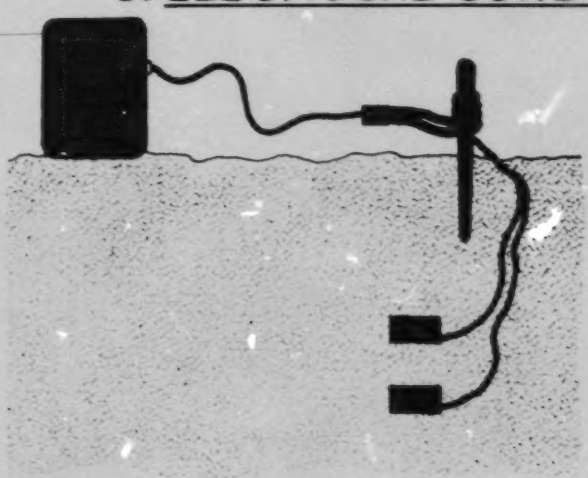
1. GRAVIMETRIC METHOD (OVEN DRYING)

$$\text{PER CENT MOISTURE} = \frac{\text{LOSS IN WEIGHT}}{\text{OVEN-DRY WEIGHT}} \times 100$$

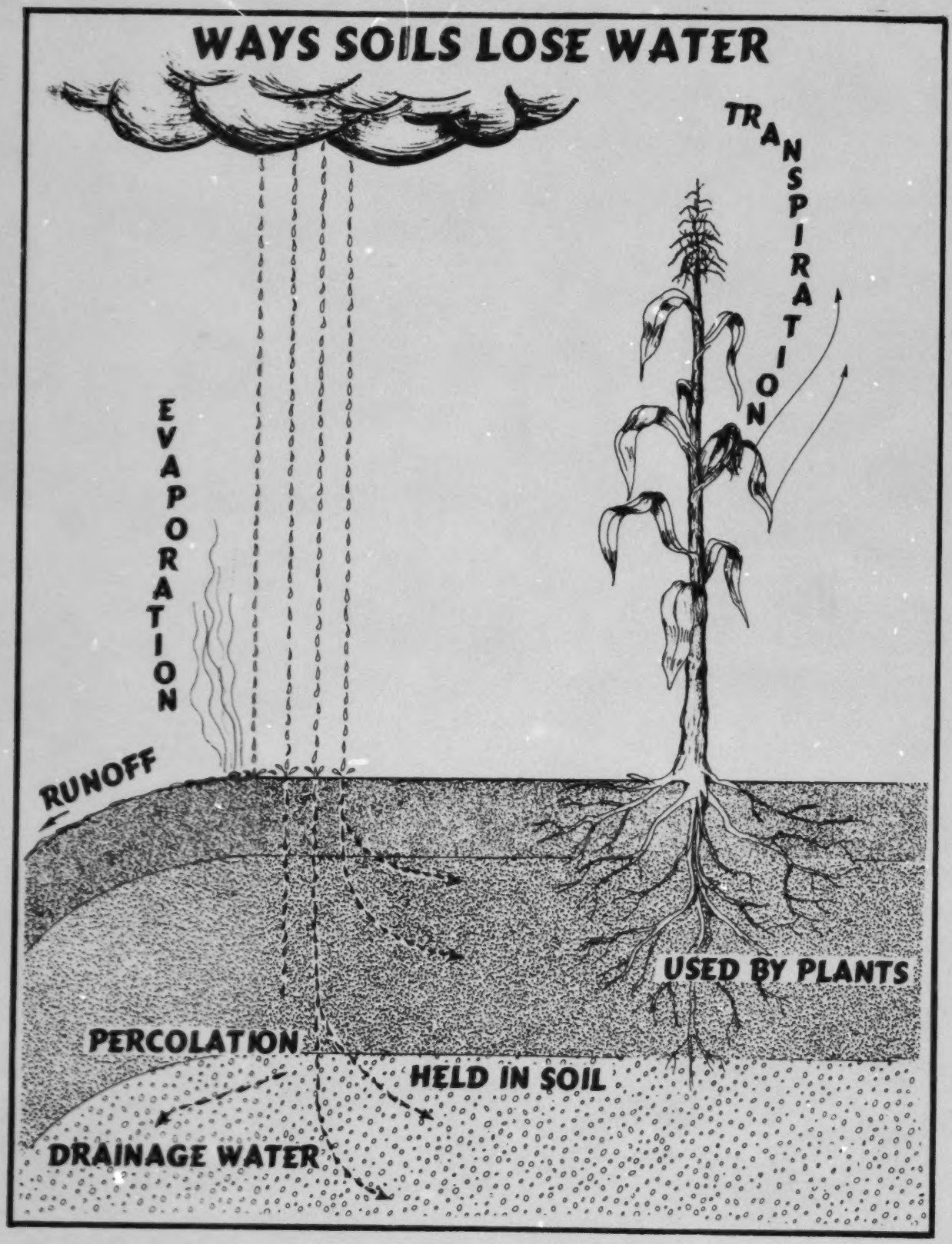
2. VACUUM GAUGE OR MERCURY MANOMETER METHOD

POROUS CLAY CUP IS FILLED WITH WATER TO MEASURE EQUILIBRIUM TENSION AS MOISTUPE MOVES THROUGH.

3. ELECTRICAL CONDUCTIVITY METHOD



AC RESISTANCE BETWEEN 2 ELECTRODES IS MEASURED.


WAYS SOILS LOSE WATER
TRANSPIRATION
EVAPORATION
RUNOFF
USED BY PLANTS
PERCOLATION
HELD IN SOIL
DRAINAGE WATER

SOIL SCIENCE

Unit D: Conserving and Controlling Soil Water

Topic 2: Soil Water Disposal

*All terms underlined are included in the "Glossary of Terms."

I. Importance of Good Drainage

A. What is soil drainage?

Soil drainage, as a natural condition of the soil, refers to the frequency and duration of periods when the soil is free of saturation. Whether a soil is said to have good drainage or poor drainage is determined by the rapidity and extent of the removal of water from the soil by runoff and by percolation through the soil.

Originally, about 216 million acres or one-fourth of the nation's potential agricultural land was too wet for farming. Many acres of this highly productive crop and pasture land have been placed in production after establishing drainage systems, and many poorly or improperly drained areas would be very productive if they were drained. Of the approximately 1.1 billion acres in farm land in 1970 about 100 million acres are located in drainage areas.

As the population of the world increases, it will be necessary to increase agricultural production to meet the demands. One way of accomplishing increased production is to provide drainage for areas with excessive water.

Drainage is also a method of conserving and controlling water and should be a part of every conservation program.

B. What are some benefits resulting from proper drainage of wet soils?

According to the Census Bureau's population projections, there will be between 236 and 277 million people in the U. S. by 1985. It is estimated that this population will be using 90 percent of the country's available water supply. To continue to grow and maintain our standard of living, this country must establish measures of conserving water; and drainage can be a part of this conservation plan.

Transparency No. 1

1. The bottomlands which are generally wet soils often have the most fertile soils on the farm. Because they are excessively wet at times through the year, they produce only part of the yield they could produce with proper drainage.
2. A wet soil is a colder soil than dry soil. This is because it takes five times more heat to raise the temperature of water one degree than is required for dry soil. Well drained soils warm earlier in the spring and permit earlier planting of crops.

3. Plants normally grow better in warm soil where there is air in the root zone. When soil is drained, the excess moisture in the soil is replaced by oxygen which increases beneficial bacterial activity.
4. Soil structure is improved by drainage. A wet soil is likely to be tight or compact and most plant roots cannot grow readily in tight soils. Also, the drying process accelerates the growth of bacteria and fungi and increases earthworm activity, all of which aid in creating more desirable soil structure.
5. Drainage allows deeper penetration of plant roots which increases the availability of soil nutrients, thus resulting in greater yields.
6. Well-drained soils permit more efficient utilization of lime and fertilizers.
7. Drainage decreases the losses of nitrogen from the soil, thus increasing the percentage of crude protein in plants. It also increases the percentage of potassium, chlorine, and magnesium in plants.
8. Drained croplands are freer from certain diseases, while drained pasturelands are less infested with parasites.
9. A wider variety of crops can be grown on properly drained soils.
10. Proper drainage makes for earlier and more efficient tractor operations. It allows field operations to begin sooner after rains, planted seeds will germinate faster resulting in better stands, and crops can be harvested earlier.

Transparency No. 2

An example of the benefits of proper soil drainage is shown in this comparison of a poorly drained soil and a well-drained soil. The plant roots in the poorly drained soil are shallow and spread out near the surface. This occurs because of the excess water near the surface in the spring and the compactness of the soil. Then as the water level drops below this root zone in the hot, droughty summer months, the crops "burn out" because the plants are not getting enough moisture. In well-drained soil, plants develop a more extensive root system which obtains water and nutrition from a larger volume of soil. The roots grow deeper into the soil, thus permitting the plants to better withstand summer droughts.

II. Nature of Drainage and Water Problems

A. Poor drainage in soils may result from overflow flooding, the catching of hillside run-off in low-lying flat land, return flow seepage on sloping land, restricted subsoil drainage, the accumulation of excess water in low areas, and a build up of the water table.

B. Drainage problems fall into four main categories:
   1. Economic—To determine whether the benefits of drainage would be economically feasible, the landowner should determine the cost of providing drainage and estimate returns.
   2. Agronomic—These considerations include the probable productivity of the acreage after drainage, adaptability of proposed crops, and additional expense and investment required in the new cropping system(s).

3. Mechanical–These considerations include such things as location and type of outlets for the main volume of runoff, size and type of drains required, grade and possible damage to other structures.
4. Legal—The planning of drainage systems frequently raises questions of legality, so legal considerations should be a part of the overall plan.

III. Soil Conditions that Require Drainage

A. Permeability and Drainage

Soils that characteristically have a slow downward movement of water often need artificial drainage because of excess surface water. (Permeability is the capacity of a soil profile to allow movement of air and water through it.) Slowly permeable soils often require artificial drainage in situations where the land surface is level and rainfall is high causing excess surface water. Soil drainage experiments in high rainfall areas have indicated that fine-texture of soils with massive structure are most in need of artificial drainage.

Permeable soils that generally do not require drainage are identified by a uniform color varying from brown to red throughout the profile. Yellow shades of subsoil indicate intermediate permeability, while clay subsoils that are gray in color are usually very slowly permeable and need artificial drainage.

B. Drainage and Ground Water Levels

A permeable soil seldom needs artificial drainage, except when the soil has a high water table. High water tables are most common in low-lying sandy soils and peat and muck soils.

1. Ground water table—The average depth of the ground water table is an important factor to consider in soil drainage and should be determined by the landowner. The ground water table is the distance from the surface of the ground to the water surface in an open hole. Generally, the ground water table, depending on the area and climatic conditions, varies from ground level to fifteen feet in depth; however, it may be much deeper in parts of Texas. The ground water table, often referred to as the "perched" water table, is not related to the deeper layers of water; and the two are separated by impervious or slowly pervious subsoils. The depth of the ground water table is a major factor to be considered by the farmer as he determines the drainage system to install on his farm.

   Providing drainage will affect only the free or surplus water and will not disturb or reduce the capillary water, which is necessary for plant growth. The opinion expressed by some that an area can be over drained is not true.
2. Recharging underground water

   The proper amount of water is always a problem of farmers and ranchers—either there is too much moisture or not enough. Seldom are moisture conditions ideal; however, they can be improved by proper management. One of the most effective methods that can be used to dispose of excessive water and at the same time conserve water is to recharge the underground water supply.

The underground water supply, according to U.S.D.A. Research Agricultural Engineers at Bushland, Texas, is being depleted rapidly by withdrawal of water to irrigate several million acres of crops each year. During the decade from 1958 to 1967, it was estimated that water storage was reduced by 35 million acre-feet to 125 million. Exhaustion of underground water is a major concern today. On the High Plains of Texas, average annual recharge in the Ogallala Formation (the major underground water source) is only one-half inch yearly, while pumpage has averaged 5 million acre-feet. Many communities throughout Texas have already had to dig more wells, and some communities and cities have had to supplement their water supply by building lakes. In order to safeguard the present underground water supply, it is very important that recharge water not be contaminated.

Several methods of recharging have been studied, and it appears that the most successful method is the use of wells. However, recharging with a pit recharge has possibilities. Another possible method of recharging the underground water supply is the spreading of water. This method may be used in areas of low rainfall and in soils that are capable of permitting the water ready access to underground storage.

IV. Drainage Systems

The two main types of drainage are surface or open ditch and subsurface or underground. The system to use will be determined by the permeability of the soil, slope of the land, cover or vegetation of the area to be drained, average depth of water table, topography, and stratigraphy.

A. The major systems of surface drainage include:

1. Open ditch drainage

Transparency No. 3

This system is probably the most used and least expensive. The farmer should keep in mind that surface ditches remove only water on the soil surface and not the water in the soil. Also, the water intake rate of the soil should be kept as high as possible so that water which could be stored will not be drained off. Otherwise, when rains are not frequent, the soils will become too dry. If this system is used, the ditch should be sodded to prevent erosion.

a. Pastureland drainage is sometimes needed to remove excess water in order to establish desirable grasses or carry out other improvement practices on the land.

b. Surface drainage of croplands may be accomplished by several methods; however, the double channel field ditch system is commonly used to remove surface water from cultivated fields. The W-ditch drainage method as shown on Transparency No. 3b has some advantages over other field

drainage systems. The advantages of the W-ditch are:

(1) Can be constructed and maintained with ordinary farm equipment,
(2) Allows better row drainage because spoil does not have to be spread,
(3) May be seeded to grass or planted to row crop,
(4) May be used as a turn row, and
(5) May serve as a field road.

The minimum spacing for the W-ditches varies from about 15 to 50 feet, depending on the size of the drains. The W-ditch is best adapted to flat land where the rows drain toward the ditch from both directions.

2. Diversion Ditches
This is a form of open ditch drainage that is used on sloping fields. (See Transparency III-C-3, No. 4.) It may be necessary to construct more than one diversion ditch in a field to handle surface water.
3. Terraces and Contours
Still another open ditch drainage system includes terraces and contours. (See Transparency III-C-3, No. 3, Terracing and Transparency III-C-3, No. 5, Contours.) These are used to remove water before it becomes a problem on crop land and pastures.

B. Types of subsurface drainage systems are:

Transparency No. 4

1. Tile drainage
This system is not widely used in Texas, possibly because of the expense involved; however, it is an effective means of draining water. Using tile drainage, the farmer places either 12 or 24 inch tile at a depth of three to six feet. The depth is determined by the amount of water to be drained, the permeability of the soil, the possibility of salt accumulation in the soil, and other factors. It is not necessary to lay several lines of tile to drain most areas.
2. Mole drainage
A cylindrical channel or mole drain is formed by pulling a ball or bullet shaped device through the soil at the bottom of a narrow blade. Mole drains are unstable and are dependent upon the stability of the soil to maintain an open channel. Mole drains have been used successfully in some areas.

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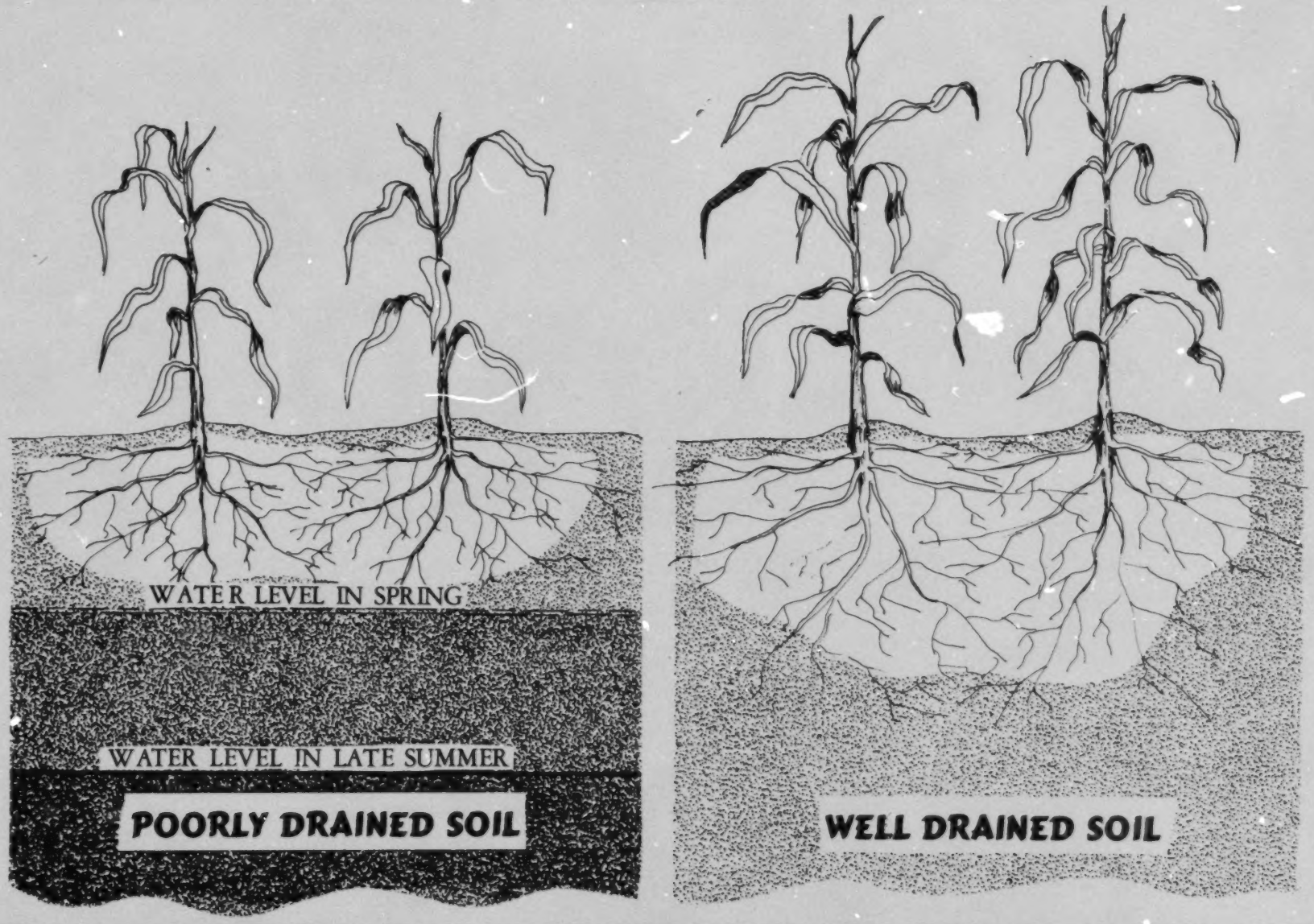
8. "Artificial Ground Water Recharge Through Basins in the Texas High Plains," MP-895, Texas Agricultural Experiment Station, Texas A&M University, College Station, TX, 1968.

PROPER DRAINAGE OF WET SOILS

benefits

1. INCREASED YIELDS ON MORE FERTILE SOILS
2. EARLIER PLANTING ON WARMER SOILS
3. INCREASED AERATION & BACTERIAL ACTIVITY
4. IMPROVED SOIL STRUCTURE
5. DEEPER ROOT PENETRATION; INCREASED AVAILABILITY OF SOIL NUTRIENTS
6. MORE EFFICIENT USE OF LIME & FERTILIZERS
7. DECREASED LOSSES OF SOIL NITROGEN; INCREASED CRUDE PROTEIN IN PLANTS
8. REDUCTION IN PLANT DISEASES & ANIMAL PARASITES
9. WIDER VARIETY OF CROPS
10. EARLIER & MORE EFFICIENT FIELD OPERATIONS

A COMPARISON OF PLANT ROOT SYSTEMS



"OPEN DITCH" SURFACE DRAINAGE SYSTEMS

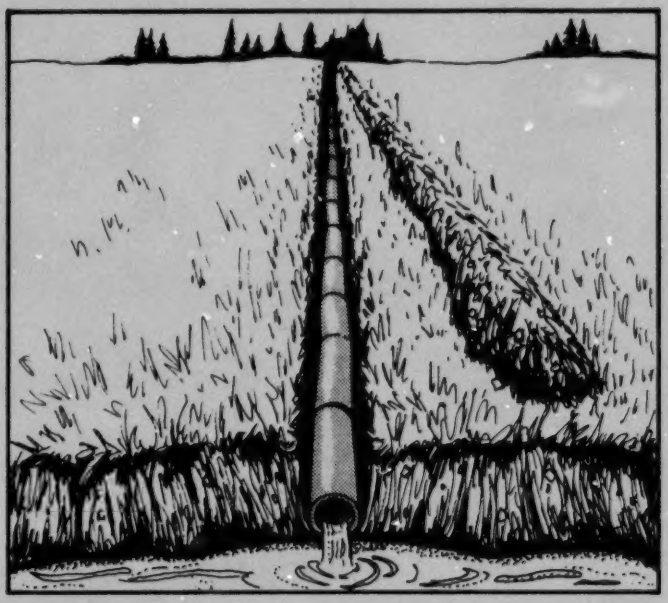
PASTURELAND DRAINAGE

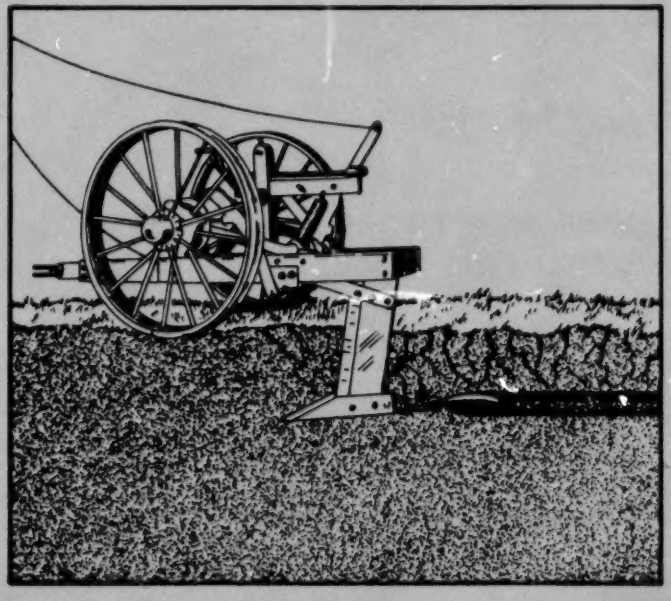
double channel "W" ditch
or twin waterway.

CROPLAND DRAINAGE

SUBSURFACE DRAINAGE SYSTEMS

TILE DRAINAGE SYSTEM





MOLE DRAINAGE SYSTEM

SOIL SCIENCE

Unit D: Conserving and Controlling Soil Water

Topic 3: Water Requirements of Crops

*All terms underlined are included in the "Glossary of Terms."

I. Soil Moisture Storage

The soil serves as a storage reservoir for moisture. It is partly solid and partly space. On a volume basis, the soil is about half solid material and half pore space, the pore space being occupied by water and air.

Transparency No. 1

A cultivated loam soil in good physical condition is comprised of approximately 50% solids and 50% pore space as shown by this illustration. Under ideal moisture conditions, the pore space would be comprised of about 25% air and 25% water. Only half of this water would be available for plant use, thus about one-eighth of the equivalent soil volume contains available water.

The mineral particles making up the solid portion of the soil are of many sizes touching each other only at certain points. The pore space not occupied by these particles will vary as to percentages of air and water. Water stored as soil moisture, which is available to the plants, is retained in the form of wedges at the point of contact and as thin films around each of the soil particles. The water is held around the soil particles by surface tension forces against the pull of gravity.

Transparency No. 2

As already indicated, water is held in soils as thin films around the soil particles. On a saturated soil, all the pore spaces are filled with water, and the soil will remain "too wet" if the water is not allowed to drain from it. Ideal moisture conditions generally exist only when there is approximately 25% air and 25% water. Under this ideal moisture condition, only half of this water is available for use by plants. As this moisture is used, the tension holding moisture to the soil particles become so great that the plants no longer can obtain water. When this moisture condition is reached, the plant permanently wilts. If the water supply is not soon replenished, the plant will die.

II. The Soil-Water-Plant Relationship

Plants live primarily on a liquid diet. Water constitutes about 75 to 90 percent of the fresh weight of growing plants. Water carries mineral nutrients and gases into the plant roots from the soil. If we understand the basic principles of water storage and movement in the soil, we may solve the problem of supplying crops with necessary water for productive growth.

Water is important in the cooling and bathing of the internal tissues of plants so that carbon dioxide may be absorbed which will help dissolve soil nutrients used by the plant itself.

Water bathes the cells continually within the plant. This assists the movement of elements needed throughout the plant.

The hydrogen content in water is also considered an important part of the compounds formed in water.

The soil serves as a storage reservoir for water. When water is in the root zone, plants can secure the water requirements needed for proper growth and development. As the plants continue to use water, the available supply diminishes, and the plants finally stop growing unless more water is added.

III. Some Factors Which Affect the Water Availability to Plants

The amount of water that can be stored in the soil and used by the plants depends upon the depth of soil occupied by the active root system of the plant and profile characteristics of the soil as texture and structure.

Fine-textured soils have more particles and more surface area than coarse-textured soils. Therefore, more water may be stored in fine-textured soils than in coarse-textured soils.

Transparency No. 3

Because there are more particles of smaller size in clay soils than in sandy soils, the fraction is larger for clays and smaller for sands. The illustration on this transparency shows the approximate available water storage per foot of depth for various textured soils.

Approximate Available Water Storage Capacity of Soils

Soil Texture	Approximate Water Inches Per Foot Depth
Sands (coarse)	½ to 1
Sandy Loams (medium)	1 to 1½
Silt and Clay Loams (medium)	1½ to 2
Clays (fine)	2 to 2½

The amount of water available to plants will also be influenced by the temperature, amount of sunshine, and rainfall in the area.

The southern part of the United States has large amounts of rainfall; however, the distribution is not uniform.

Transparency No. 4

Texas has a wide variation in the amount of rainfall. This extreme rainfall variation will have a great influence on the type of crops grown throughout the state. Crops grown in the western section of the state will usually be (except in irrigation areas) those that require the least amount of moisture to produce them. Many of the crops grown in the eastern section of the state will require large amounts of moisture.

IV. Some Factors Which Affect the Water Requirement of Plants

A. Of all the materials used by the plant for its growth and maintenance, water is taken up in the largest amount. The total quantity of water removed from the soil by a growing plant is large in comparison to the amount present in the plant at any one time. The bulk of the water absorbed by the plant through the roots is not retained but evaporates into the air from the leaves. This water loss by evaporation is known as transpiration.

Transparency No. 5

The amount of water required by various crops to produce a pound of dry matter is known as the transpiration ratio. Transpiration ratios vary depending on location and climatic conditions. In general, more water is transpired by plants grown in hot, dry climates than under cool, moist conditions. Considerable variation exists among different species of plants in the amount of water required for normal growth.

B. The water requirement of individual crop plants is greatly influenced by prevailing climatic conditions. As already stated, plants grown in hot, dry climates transpire more than plants grown under cool, moist conditions. For example, the same crop grown under different climatic conditions will require differing amounts of water to produce the same yield.

C. The fertility of the soil will affect the amount of water used by plants in their growth. Because yields are higher on fertile soils, the total water requirement for plants grown on fertile soils is greater than for plants grown on relatively infertile soils. However, per unit of production, the plants grown on fertile soils make much more efficient use of water than those grown on poor soils.

D. The growing season and growing habits of the plants will affect the water requirement of various crops because the demand periods and seasonal requirements will vary considerably.

E. The type of root system is another factor that will determine the amount of water required for any given crop. The two types of root systems of plants are fibrous roots and taproots. Some examples of these types of root systems are:
1. Fibrous—corn, oats, wheat, and grasses.
2. Taproot—Cotton, beans, and tobacco.

WATER REQUIREMENTS OF TEXAS CROPS

CROP[1]	CRITICAL WATER DEMAND PERIODS[2]	APPROXIMATE WATER USE IN INCHES PER DAY[3]	WATER REQUIREMENT INCHES[4]
COTTON	BLOOM STAGE UNTIL ABOUT 1/2 TO 3/4 OF BOLLS ARE MATURE	0.25 - 0.40	15 - 26
CORN	TASSELING-SILK STAGE UNTIL GRAIN BECOMES FIRM	0.20 - 0.28 0.28 - 0.38	8 - 12 HUMID 15 - 22 SEMI-ARID
GRAIN SORGHUM	BOOT, BLOOM AND MILK-DOUGH STAGES	0.25 - 0.40	16 - 20
WHEAT-SPRING	BOOT, BLOOM AND EARLY HEAD STAGES	0.22 - 0.35	14 - 22
TOMATOES	BLOOM AND FRUIT ENLARGEMENT PERIOD	0.25 - 0.35	12 - 18
LETTUCE AND CABBAGE	HEAD FORMATION UNTIL THEY BECOME FIRM	0.17 - 0.20	7 - 12
IRISH POTATOES	TUBER SWELLING PERIOD	0.16 - 0.20	12 - 15
CARROTS	WHEN ROOT ENLARGEMENT AND SWELLING STARTS	0.15 - 0.19	8 - 10
ONIONS	BULB FORMATION TO MATURITY	0.15 - 0.20	10 - 12
ALFALFA	BLOOM AND SEED FORMING	0.27 - 0.40	30 - 50
SOYBEANS	BLOOM AND SEED FORMATION	0.25 - 0.35	22 - 26
CASTOR BEANS	BLOOM STAGE TO PHYSIOLOGICAL MATURITY	0.33 - 0.40	25 - 30
PEANUTS	PRIOR TO AND DURING TIME NUTS START TO FORM	0.22 - 0.25	6 - 12
PERENNIAL GRASSES	SEED HEAD FORMATION	0.25 - 0.25	25 - 35
LEGUMES	BLOOM & SEED FORMING-SUMMER	0.22 - 0.33	15 - 24
WATER	BLOOM & SEED FORMING-WINTER	0.13 - 0.19	12 - 16
RICE	HEAD FORMATION & FILLING	0.25 - 0.30	35 - 45
PEACHES	FRUIT SETTING & FRUIT SWELLING	0.22 - 0.26	22 - 30
ORANGE AND GRAPEFRUIT	FRUIT SETTING & ENLARGEMENT STAGES	0.25 - 0.35	30-40

Transparency No. 6

1. The crops listed are only a cross-section of the different ones grown throughout the state.
2. Periods based on the stage of growth in which a lack of soil moisture probably would be most detrimental to yield or quality or both.
3. Daily evapo-transpiration rate (approximate). These are expected average maximum daily water use values for the individual crops. Generally, the periods of maximum water use for most crops will be during the bloom and fruiting stages of growth. In some cases it may extend about half through the maturing stage. Because of the wide variation in climate, soils, crops, varieties, and planting dates throughout Texas, these values are somewhat general.
4. The water requirement values shown are usually the extremes which can be expected. Also remember that the total amount of water specified is the requirement from time of planting until complete production of the crop. For ideal conditions, this water must be available only in certain portions of the total amount through the development and production of the crop. Remember that the water-holding capacity of the soil will cause some areas to require moisture than others. The smaller requirement inches apply to the more humid regions, while the larger requirement inches are to be applied to the semi-arid regions of Texas. When saline soils and water are encountered, the requirement will be increased 20 to 50 percent and even more in such areas as the transpecos.

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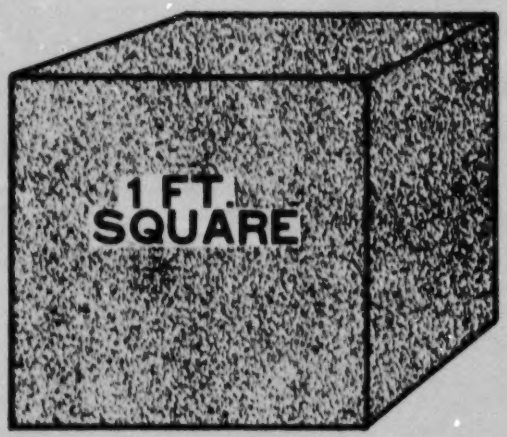
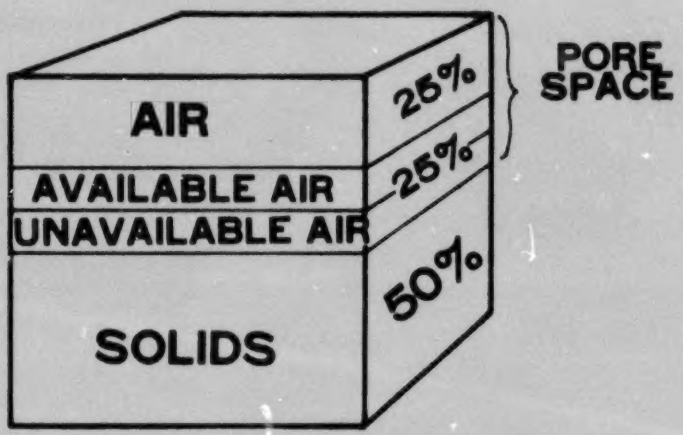
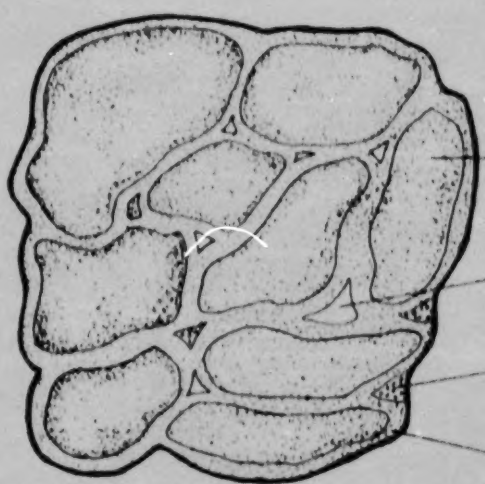




SOIL MOISTURE STORAGE



SOIL PARTICLE (MINERAL)

AERATION PORE SPACE

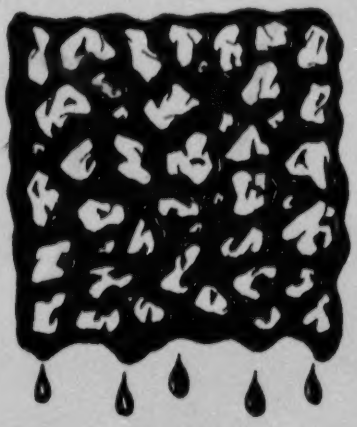
CAPILLARY WATER

WATER FILM

SOIL MOISTURE CONDITIONS

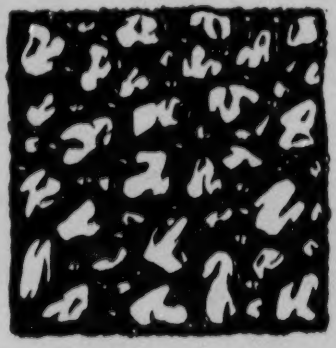
SATURATION

(TOO WET)



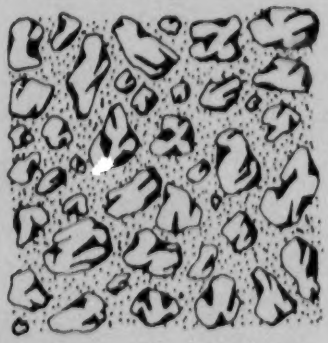
FIELD CAPACITY

(IDEAL)

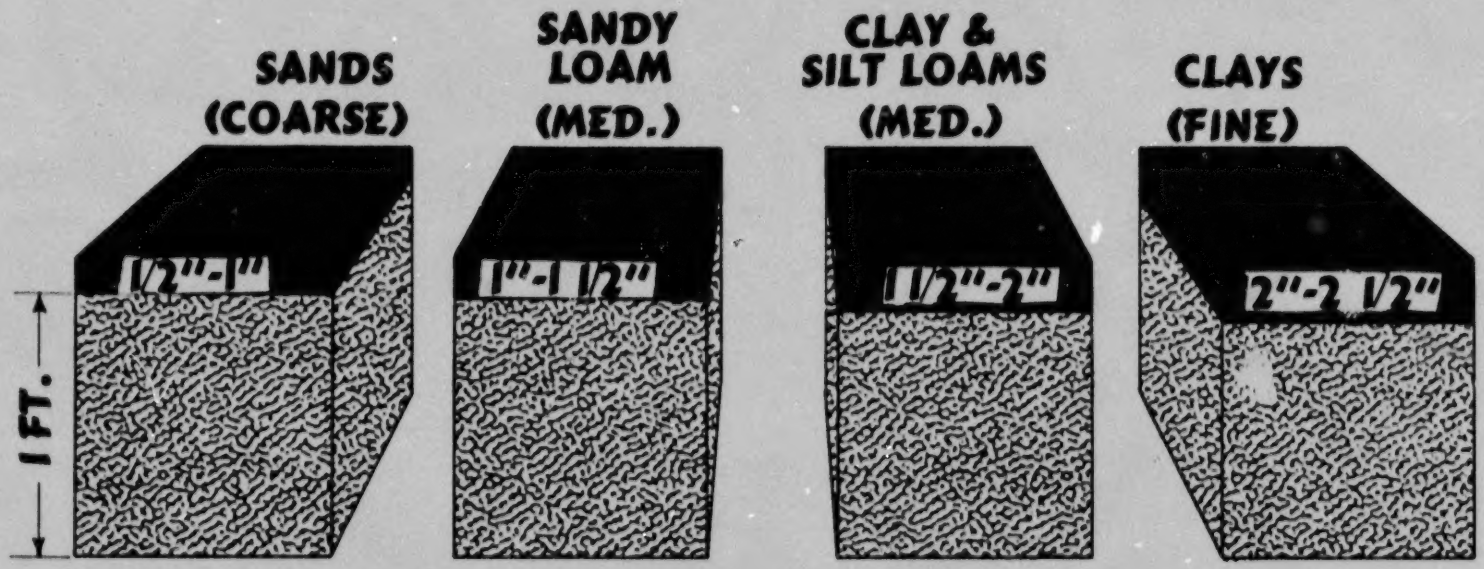


WILTING POINT

(TOO DRY)



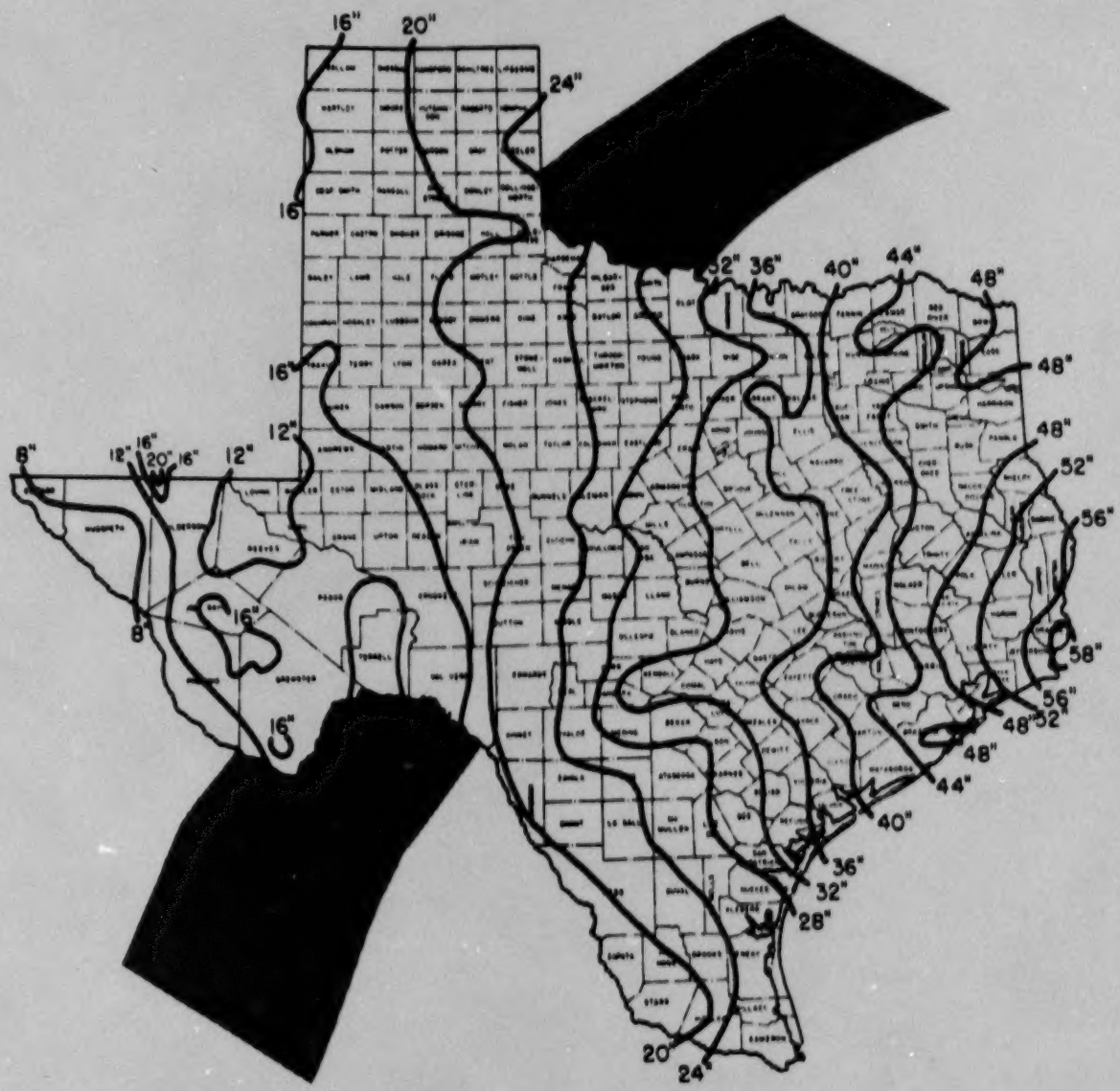
AVAILABLE MOISTURE STORAGE CAPACITY...



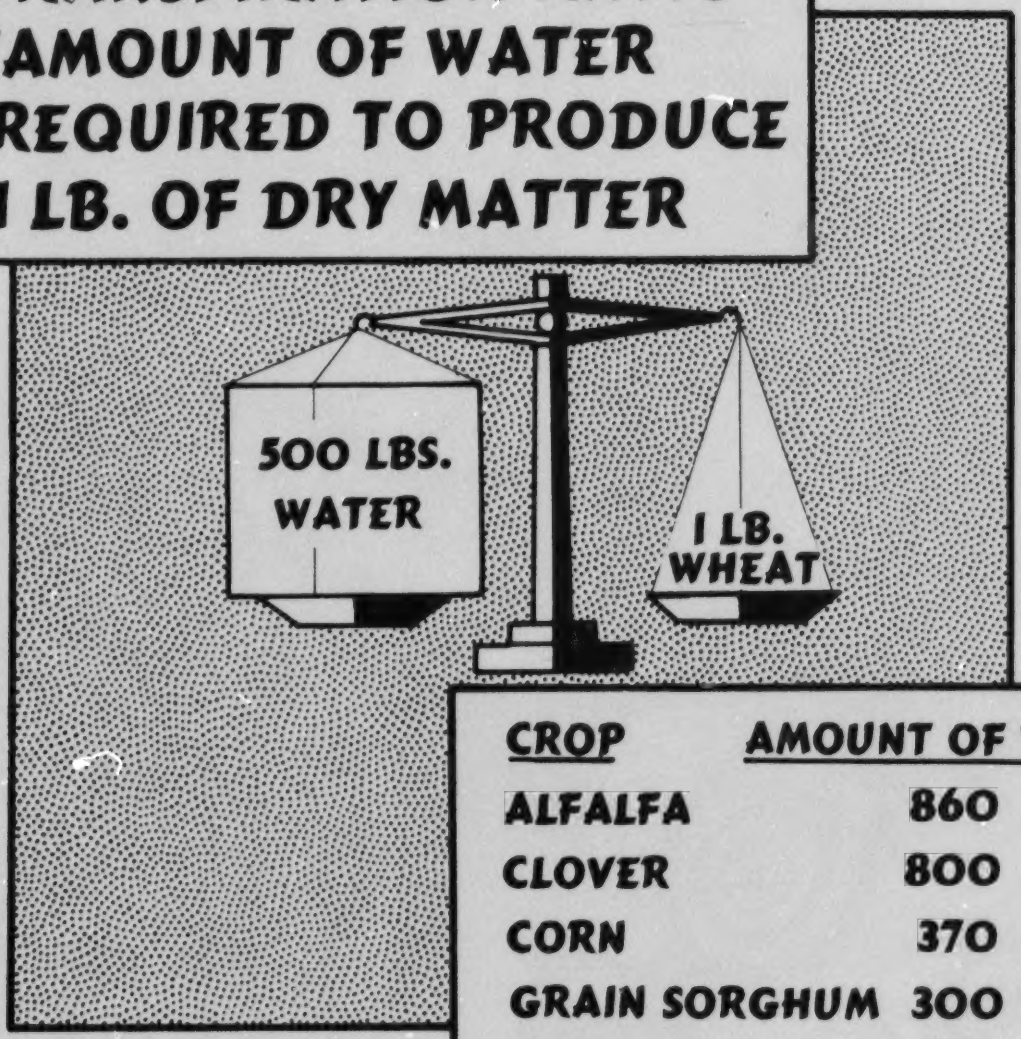
(PER FOOT OF DEPTH)

... FOR VARIOUS TEXTURED SOILS

RAINFALL DISTRIBUTION IN TEXAS

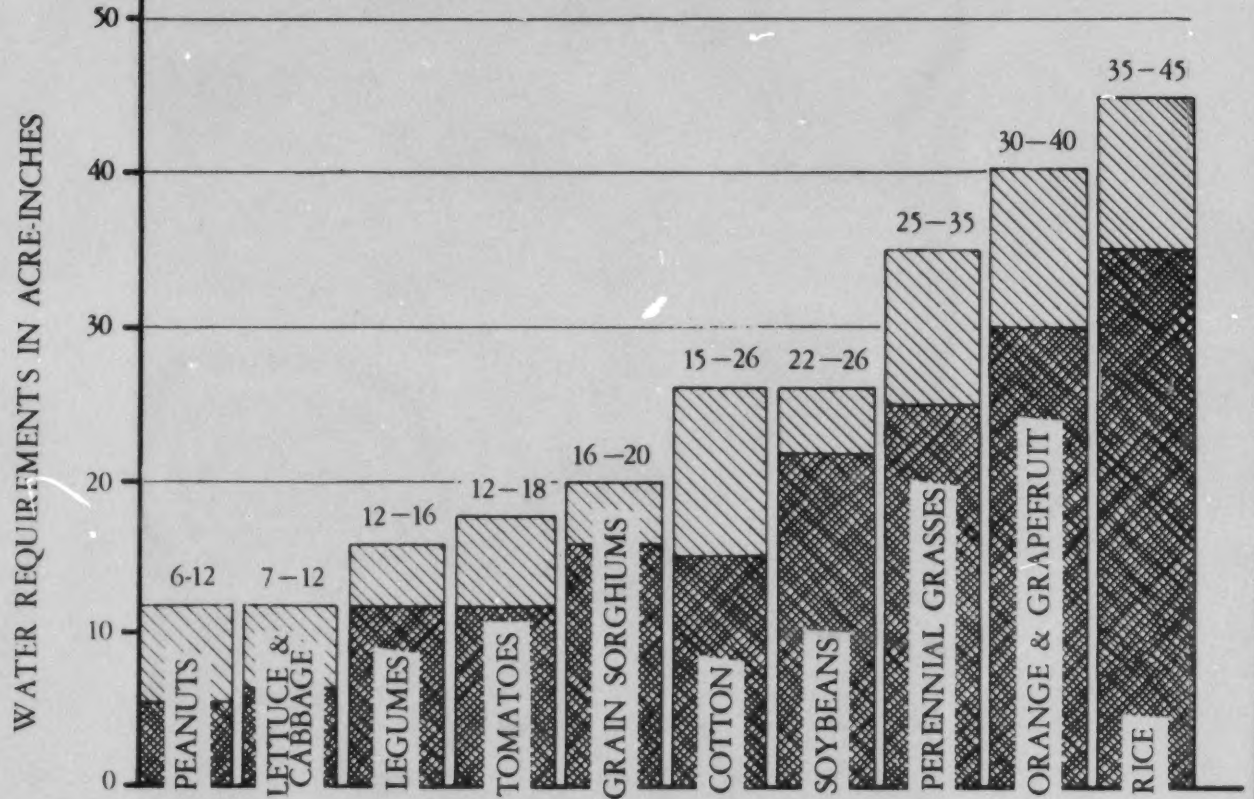


TRANSPIRATION RATIO– (AMOUNT OF WATER REQUIRED TO PRODUCE 1 LB. OF DRY MATTER



CROP	AMOUNT OF WATER (POUNDS)
ALFALFA	860
CLOVER	800
CORN	370
GRAIN SORGHUM	300
OATS	600
POTATOES	630
SOYBEANS	770
WHEAT	500

WATER REQUIREMENTS OF SOME TEXAS CROPS



THE RANGE SPECIFIES THE AMOUNT OF WATER NEEDED FROM PLANTING UNTIL HARVEST.

SOIL SCIENCE

Unit D: Conserving and Controlling Soil Water

Topic 4: Conservation Measures

* All terms underlined are included in the "Glossary of Terms."

I. Characteristics Affecting the Management of Soil Water

There are three basic problems relating to characteristics of soil water which the farmer or rancher must consider in the management or conservation of soil water: (1) increasing water entry into the soil, (2) improving soil water movement, and (3) increasing water storage capacity.

A. Increasing Water Entry into the Soil
What really counts in a rain is how much of it enters the soil.

Transparency No. 1

There are five major factors that affect intake of water by the soil.

1. The duration of rainfall or application of water
2. The season of the year and temperature of soil and water. Infiltration tends to be higher in the warm months than in the cool months.
3. Surface condition and amount of protection against the impact of rain. Rain on bare soils breaks up soil aggregates, leaving a compact, dense surface layer which slows movement of water into the soil.
4. The moisture content and degree of saturation
5. Internal characteristics of the soil mass, including pore size, depth or thickness of the permeable portion, degree of swelling of clay particles, content of organic matter, and degree of aggregation. Soil characteristics that primarily govern infiltration are the physical properties like texture and depth to the slowly permeable horizons. Some of the highest rates of infiltration occur on deep sands or on deep silt loam soils that are highly aggregated and therefore have relatively large pores. Clay soils with a high degree of swelling when wet can be expected to have a much lower rate of water intake.

This illustration shows the factors that affect the infiltration of water into the soil. These same factors are related to the amount of rainfall that runs off and may cause erosion.

Of the five factors mentioned, the ones readily modified by man's action are those dealing with the surface condition of the soil and its protection against rain impact. An ideal soil allows water to enter as rapidly as it rains under normal conditions.

B. Improving Soil Water Movement
Soil water movement is mainly controlled by such factors as soil structure, aeration (air spaces), and the behavior of soil water in relation to soil particles.

As water is held in capillary spaces between soil particles or aggregates and as films on their surfaces, the soil pores (air spaces) provide passages for plant roots, air, and water.

Transparency No. 2

Though gravity moves soil water downward, the forces between soil particles and water molecules act without regard to direction. Gravitational water is free to move downward under the force of gravity. Capillary water may move in any direction in response to capillary tension. Both gravitational water and capillary water can be removed from the soil by plant roots. Hygroscopic water has no movement and is unavailable for plant use.

Soil moixture is attracted to soil particles much as steel particles are attracted to a magnet. The water film closest to the soil particle is held with enough tension that it is unavailable to plants. As the water layer on the soil particle becomes thicker, the water near the outside of the layer is not as strongly attached to the soil particle.

The behavior of soil water in relation to soil particles, then, can be explained on the basis of adhesion and cohesion. Adhesion in this case is the force that attracts molecules of water to molecules of soil. Cohesion is the force that attracts molecules of water to one another. Water molecules at the outside of thicker water layers move away to water layers that are thinner. Thus, water molecules are attracted to soil particles directly by adhesion and indirectly by cohesion.

There is a tendency for water to move from areas where the water films are thick to areas where they are thin. This causes water to move into a dry soil. Water moves more rapidly when moisture films are thick, but as the films become thinner, the rate of movement slows. As this drying takes place, water does not move over a fraction of an inch to provide moisture to plant roots. Thus, plant roots must be well distributed through the soil to make maximum use of soil moisture.

C. Increasing Water Storage Capacity

The major factors affecting water storage capacity are texture, structure, and organic matter.

1. Texture—As we have already discussed, water is held in soil by forces attracting it to the surface of the soil particles; therefore, the greater the surface area of soil particles, the more water the soil will hold. Thus, a soil which consists mostly of coarse particles has a low ability to hold water, whereas finer soils hold more water. (Refer to III-D-3, Transparency No. 3.)

   From this illustration, we conclude that sandy soils have low water-holding capacity in comparison with clayey soils.

2. Structure—The arrangement of soil particles will determine to some degree the water storage capacity of a soil with reference to its surface area. A loosely arranged soil with a higher percentage of pore space will absorb water more readily; however, a fine-textured soil can store greater amounts of available water. Loamy soils often store larger amounts of water than clay soils

with superior moisture storage capacity, simply because loamy soils permit more water to enter.

3. Organic matter—Organic matter has a tremendous influence on the water-holding capacity of a soil because it will hold water equivalent to an amount several times its weight. Organic matter influences water-holding capacity indirectly by increasing the pore space in fine-textured soils and by helping to fill in between large pores to increase the number of capillaries in coarse-textured soils.

II. Recommended Practices for the Conservation of Soil Water

After gaining some insight into the basic problems which the farmer or rancher must consider in the conservation of soil water, let's consider some practices which might be used to increase the availability and efficiency of soil water for plant growth.

Transparency No. 3

A. Remove Excess Water
An over supply of water is as bad as a shortage of water. The excess water on the soil cuts down the supply of oxygen needed by plants. An over supply of water in arid regions may cause a build up of salts on the top region of the soil. In irrigation regions salt may also build up on the surface of the soil.

B. Prepare Soil for Proper Infiltration
Infiltration means that the soil is capable of absorbing moisture.

Proper plowing and timing of plowing may help rearrange the structure of soil that is incapable of infiltrating proper amounts of water.

Crop residues on top of the soil may help the soil infiltrate water. Green manure and cover crops help add organic matter which increases the soil infiltration capacity.

C. Controlling Runoff of Water
The control of the runoff water will also decrease soil erosion problems, as well as help conserve soil moisture.

Improved farming practices such as:

(1) Contour farming	(4) Strip cropping
(2) Terracing	(5) Others
(3) Drainage	may cause soil moisture.

D. Weed Control on Crop Land
Weeds absorb water just the same as crops. In fact, weeds require more moisture to produce a pound of dry material than do crop plants.

E. Fallowing Crop Land
Fallowing of crop land means that the soil is cultivated but is not used for the production of any crop for a season.

The cultivation of the soil destroys many of the weeds and assists the soil in building up a supply of moisture.

It may also be noted that moisture content may be built up due to the lack of a crop being planted.

F. Crop rotation may be helpful in conserving soil moisture. Crops that require less water may be followed by additional crops with small losses of soil moisture.

G. Adequate fertility is essential for efficient use of soil moisture.

Proper distribution of adequate amounts of all essential nutrients in the soil permits plants to make more effective use of limited moisture supplies in surface soil and also to extend their roots into subsoils for stored moisture.

The lack of necessary plant nutrients lowers the efficiency of water use by plants.

H. Storage tanks are also methods of conserving and controlling soil moisture.

Tanks may be used to supply moisture to the soil during drought periods. If this method (tank storage) of soil water conservation is used, a farmer would be wise to contact his soil conservation service office for expert advice.

III. Application of Water Conservation Practices

The rate of growth of plants is directly related to the available moisture in the soil. The ideal soil for plant growth from the standpoint of water supply is one that takes in the water that falls, allows the excess to drain away, and holds enough for plant use between periods of rainfall.

The following is a brief discussion of some conservation measures which may be used depending on the land use.

A. Field Crops and Water Conservation

1. In annual cropping an effort should be made to provide a good plant cover during the parts of the season that major crops are not grown. A good ground cover increases water intake.
2. Crop residues and mulches of hay or straw have proved to be a good substitute for plant cover in cultivated fields.
3. Some farmers protect their soils by leaving standing stubble in the fall and during fallow periods.
4. Control of weeds and nonbeneficial vegetation helps to conserve soil water losses from transpiration.
5. Infiltration rates of water have been found to be improved under a rotational cropping system.
6. The use of selected mechanical practices will help reduce water runoff and increase water intake.

B. Grassland and Water Conservation
   1. Desirable grass stands and production of forage can be improved by controlling undesirable weeds, brush, and trees which use valuable soil moisture.
   2. Grasses protect the soil from erosion and hold more runoff water, thus allowing more of it to enter the soil.
   3. Grass plants and roots help to maintain the humus and organic matter content in the soil.
   4. Grasses become dormant earlier in the fall; therefore, more water is stored in the soil for early spring growth.

C. Forests and Water Conservation
   1. Properly managed forest stands reduce water runoff, and thereby help control water runoff and reduce soil erosion.
   2. Selective harvesting of the trees will allow rainfall to reach the soil, and also will reduce the water transpiration loss from undesirable trees.
   3. Forest stands reduce soil and soil water evaporation losses from windstorms by providing a protective cover for the soil.

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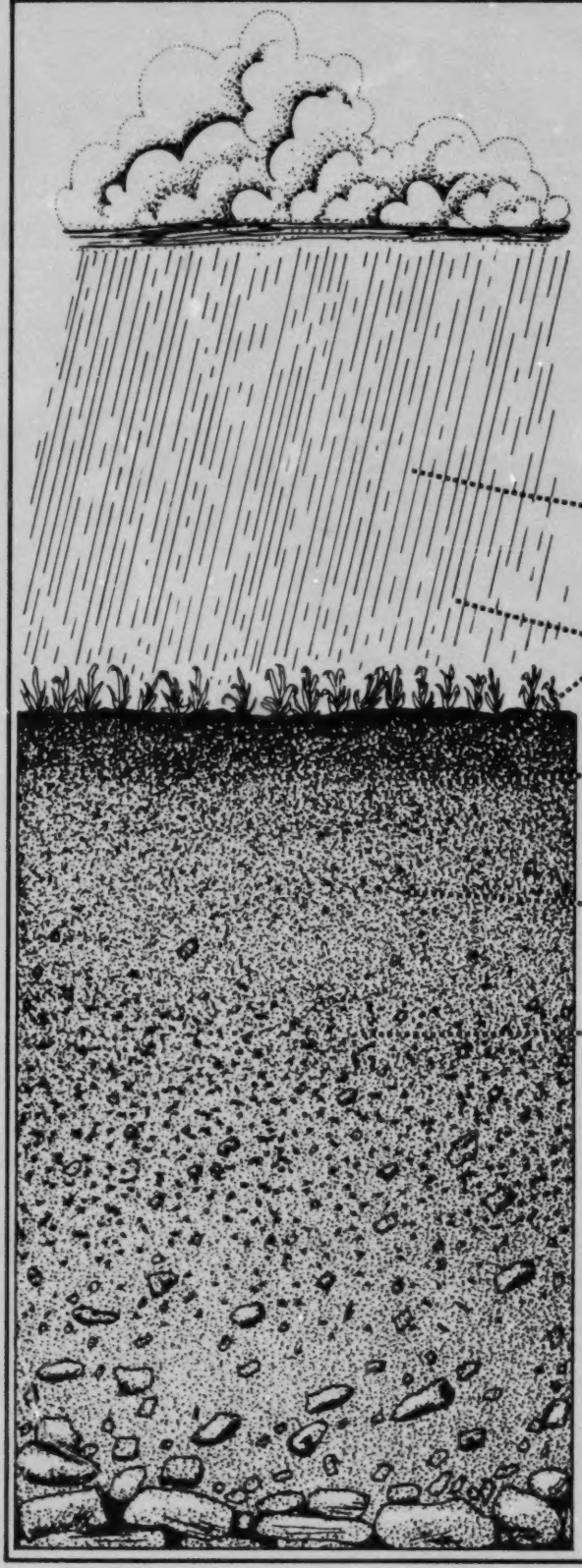
FACTORS AFFECTING SOIL INTAKE OF WATER



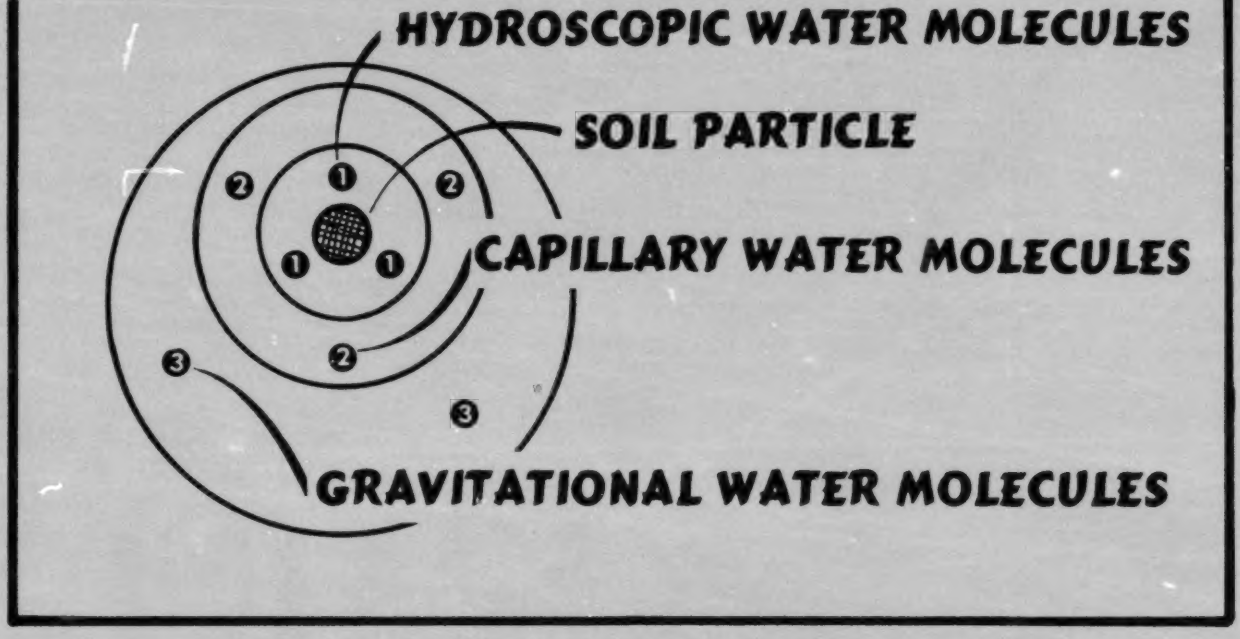
intensity and duration of rainfall

temperature of soil and water

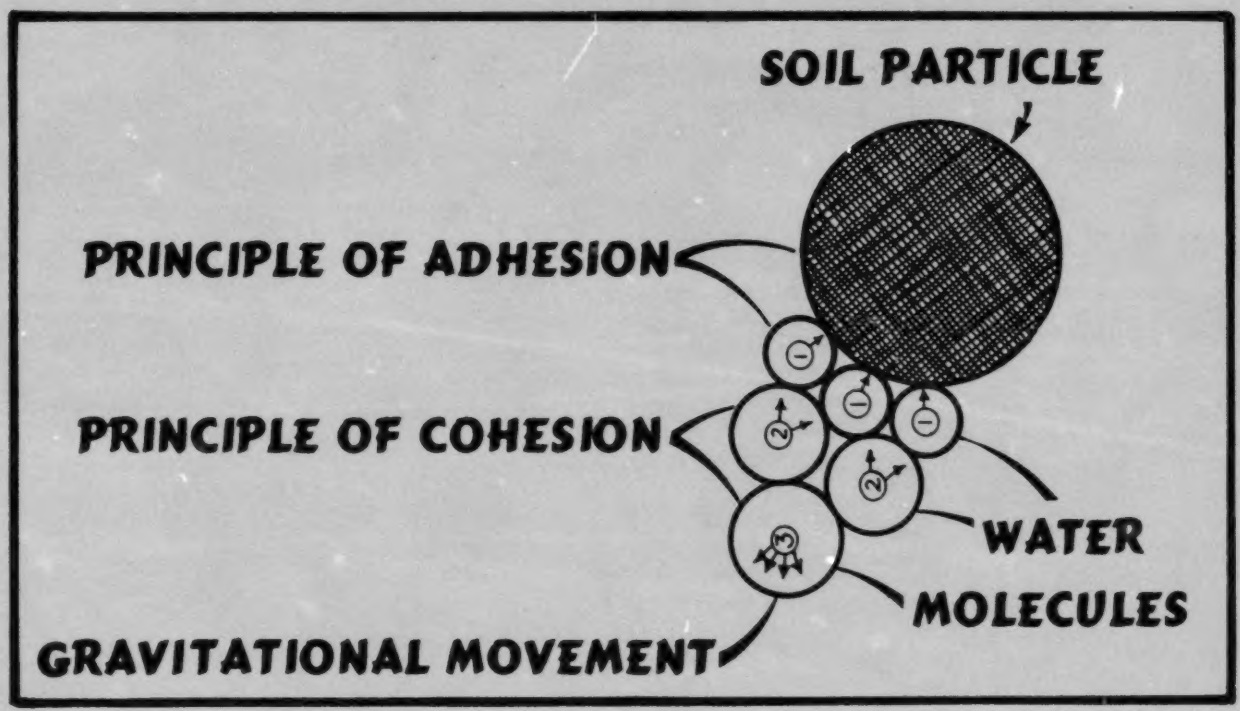
topsoil type and condition

content moisture

permeability of the subsoil



SOIL WATER MOVEMENT



SUGGESTED PRACTICES FOR CONSERVATION OF SOIL MOISTURE

1. REMOVE EXCESS WATER
2. PREPARE SOIL FOR PROPER INFILTRATION
3. CONTROL RUNOFF WATER
4. CONTROL WEEDS
5. FALLOW CROPLAND
6. ROTATE CROPS
7. PROVIDE ADEQUATE FERTILITY
8. USE STORAGE TANKS

GLOSSARY OF TERMS

1. Adhesion—Molecular attraction which holds the surfaces of two substances in contact, such as water and soil particles.
2. Aeration—The movement of air or oxygen in the soil.
3. Available moisture—The water hold in a soil between field capacity and the permanent wilting point, and generally considered that portion of water which can be absorbed by plant roots.
4. "C" Layer—Soils are composed of one or more layers. The "A" layer is the surface, the "B" layer is the subsoil, and the "C" layer is the underlying parent material above bedrock.
5. Cleavage—The tendency of crystalline rocks or mineral particles to split along thin parallel lines into thin sheets which may be highly inclined to be the planes, as in slate.
6. Cohesion—The force that attracts or holds molecules of water (liquids or solids) together, owing to the attraction between like molecules.
7. Degree of Aggregation—Soil aggregation is the binding together (cohering) of groups of soil particles into clusters or masses such as a clod, crumb, or block. The degree of aggregation in soils refers to the extent of water-stable aggregates which will not disintegrate easily and are of special importance to soil structure.
8. Eluviation—The removal of soil material in solution (or in suspension) from a layer of soil. Usually, the loss of material in solution is described by the term leaching.
9. Fallow—Allowing cropland to lie idle for the greater part of a growing season in order to restore productivity through the accumulation of water, nutrients, or both.
10. Field Capacity—The amount of moisture remaining in a soil after the free or gravitational water has been allowed to drain away into drier soil material beneath.
11. Floc—A cluster of soil. Flocculation is the process by which very fine particles of soil in a solution collect in larger masses and eventually settle out of suspension.
12. Hydromorphic—Developed in the presence of an excess of moisture which tends to suppress aerobic factors in soil building.
13. Impervious—A soil that will not absorb water or through plant roots cannot penetrate.
14. Infiltration—The downward entry of water into a soil. Infiltration rate denotes how rapidly a soil will absorb water.
15. Leaching—The removal of soluble materials from the soil by the action of water passing through the soil.
16. Parent Material—The unconsolidated mass of mineral or rock material from which the upper layers of the soil profile develops.

Glossary of Terms
(Continued)

17. Percolation—The downward movement of water through the soil in response to the pull of gravity.

18. Permanent Wilt—The water content of soil on an oven-dry basis at which plants wilt and fail to recover their turgidity when placed in a dark humid atmosphere. Permanent wilt exists when plants remain in a wilted stage day and night.

19. Permeable—Refers to the ability of soil to be penetrated by air and water.

20. Physiographic—Physical geography or a general description of nature or natural phenomena.

21. Pit recharge—The draining of excess water into a large pit; the pit must permit the water to enter the underground storage area.

22. Podzolic—Soils formed in cool-temperate, humid climates under coniferous or mixed forest and characterized by a highly leached, whitish gray A2 horizon.

23. Pore Space—Total space not occupied by soil particles in a volume of soil, commonly expressed as a percentage. The percent pore space is equal to

$$100 - \frac{\text{Bulk density}}{\text{Particle density}} \times 100$$

24. Residual—Refers to the soils formed in materials from bedrock that have not been moved or transported from the original location.

25. Saturated Soil—A soil at the point that it does not have the capacity to absorb and hold any more water without losing an equal amount.

26. Saturation—A condition in which water fills all the pore spaces of a soil.

27. Soil Profile—A vertical section of the soil from the surface through all its horizons, including C horizons.

28. Soil Tilth—The condition of the soil structure. Soils that have a good structure and are easy to work and have a good tilth.

29. Spoil—Soil or rock material removed from a canal, drainage ditch, diversion, or similar construction.

30. Spreading of Water—Spreading excessive runoff water over a large land area to replenish the underground water supply. The soil in this area must also permit the water to enter the underground storage area.

31. Stratigraphy—The arrangement of the soil strata.

32. Transpiration—The process by which water vapor is released to the atmosphere by the leaves or other parts of a living plant.

33. Topography—The shape of the ground surface as determined by such major features as hills, mountains, or large plains. "Steep" topography and "flat" topography

Glossary of Terms
(Continued)

are examples of terms commonly used to indicate slope of the land.

34. Water Table—The upper surface of ground water or that level below which the soil is saturated with water.

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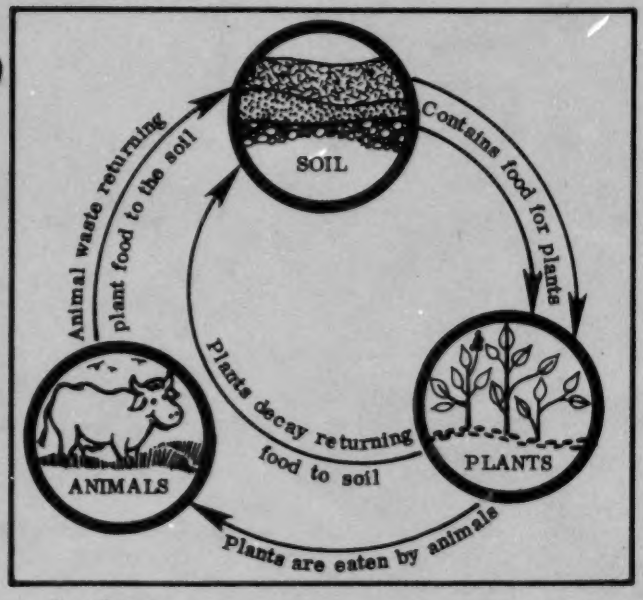
SOILS - INFLUENCE AND FORMATION

I. INFLUENCE OF SOILS

A. United States

The nation's soils have been the foundation of our independence, safety, and welfare. Much of our nation's greatness is due to the productive capacity of its soils. Our soils contribute to the production of happiness, progress, and prosperity that all Americans are able to enjoy.

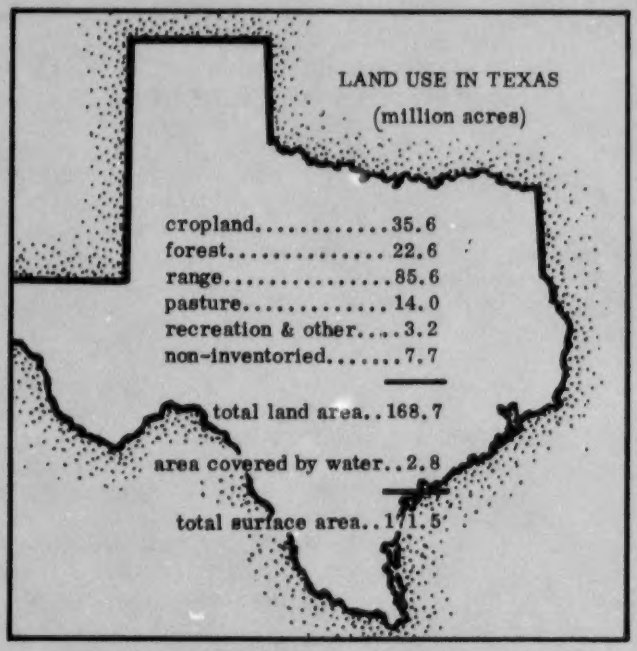
America is one of the few nations in the world today that produces enough food to sustain its population. The soils contribute the food in wartime that enables us to maintain troops in other lands. In peace time, food is sent to millions of hungry people in other parts of the world. The production of food is dependent upon the ability of our soils to sustain plant life. Soil is the original source of most nutrients for all plant and animal life.



B. Texas

In Texas soils are a vital natural resource for the production of food, forage, trees, and fiber and for development related to industry, recreation, housing, transportation, and water resources.

Texas has a total surface area of 171.5 million acres of which about 168.7 million acres is land and 2.8 million acres is covered with water.



Of this total land area, Texas is endowed with 36 million acres that are well suited for crop production. More than 8 million acres of this cropland are irrigated. Approximately 23 million acres, mostly in East Texas, are classified as forest land. About 12 million acres of this forest land produce commercial lumber, veneer, poles, piling, fiberboard, paper, and other pulp products. Nearly two-thirds of Texas or about 100 million acres are used primarily for grazing. Approximately 86 percent of these acres are classified as rangelands which have volunteer pasturage, while the other 14 percent of the acreage is vegetated primarily with introduced grasses and is considered pastureland.

Water use requirements for municipal, domestic, industrial, agricultural, and recreational purposes become greater each year with increasing population and industrial expansion. To help meet these demands, water reservoirs now cover about 1.3 million acres of the total 2.8 million land acres covered by water.

In addition to the land uses already mentioned, there are 3.2 million acres of land and water used for outdoor recreation in Texas, which are subject to administrative control by state and federal agencies.

II. PERMANENCE OF SOILS

Soil only appears to be changeless and permanent. Actually, something is constantly being added or taken away from the soil. These changes tend to balance each other; therefore, soils appear to be stable.

The formation of soils is a long and slow process. It usually takes nature hundreds of years to develop one inch of topsoil. This much could be easily lost in one heavy rain. The Mississippi River alone deposits 730,000,000 tons of soil into the Gulf of Mexico each year.

This is only a small part of the total amount lost each year. If America is to maintain her productive soils that play such an important part in her well being, her people must have an understanding of what makes soils productive and practices that will keep them that way.

III. FACTORS AFFECTING SOIL FORMATION

Soils form at the earth's surface as the atmosphere, sunlight, water, and living things meet and interact with the mineral world. At this junction, plants attach themselves to the soil, grow, photosynthesize their food, and give off oxygen. Plants and animals, large to microscopic in size, live on and in the soil utilizing carbon dioxide, oxygen, water, mineral matter, other plants and animals, and their decomposition products. All land based life and its continuation is thus made possible. Man is a part of this system; his life depends on it too.

Soils vary in their temperature and in the amounts of organic matter, air, and water they contain. The kinds of soils formed at a specific site are determined by the interacting effects of (1) climate, (2) organisms (plants and animals), (3) parent soil material, (4) topography, and (5) weathering, each of which is imposed under local conditions. These five interactants are called "the soil forming factors."

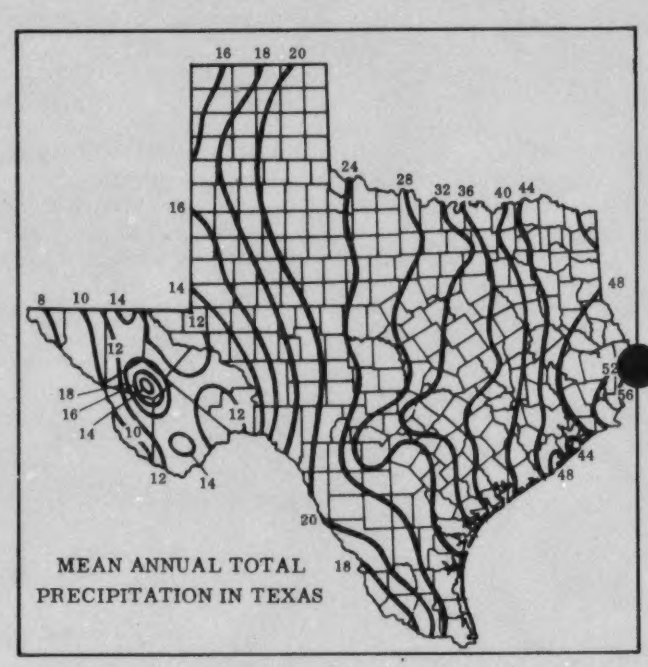
As would be expected, these factors are interrelated-that is, each one affects others and is affected by others. Consequently, all have been responsible, at least in part, for the characteristics of our present-day soils. In short, the different soils are formed by different combinations of these factors. How they influence soil formation is discussed in the following paragraphs.

A. Climate

Temperature and rainfall greatly affect the rate of weathering. When temperature rises, the rate of chemical reactions increases and growth of fungi, soil bacteria, and plants increases.

For example, in the far North the rate of decomposition of organic matter is so slow that some of it never decomposes. In other words, it remains in a partially decomposed state and is known as "peat."

The rate and amount of rainfall in a locality greatly affect the soil. In areas of high rainfall, the soils are usually-but not always-leached*and acid. When rain or snow falls during cold weather, they have less effect on the soil than rainfall during warm or hot weather.



MEAN ANNUAL TOTAL PRECIPITATION IN TEXAS

Warmer conditions stimulate biological and chemical actions in the soil. Also, the rapidity or intensity of the rainfall greatly influences the soil by erosion and/or overflowing.

Slope and location of a field also affect erosion and drainage. Moreover, "free" water in the soil not only tends to produce "layering" but also affects the growth of fungi and bacteria.

*Underlined words are defined in the "Glossary of Terms"

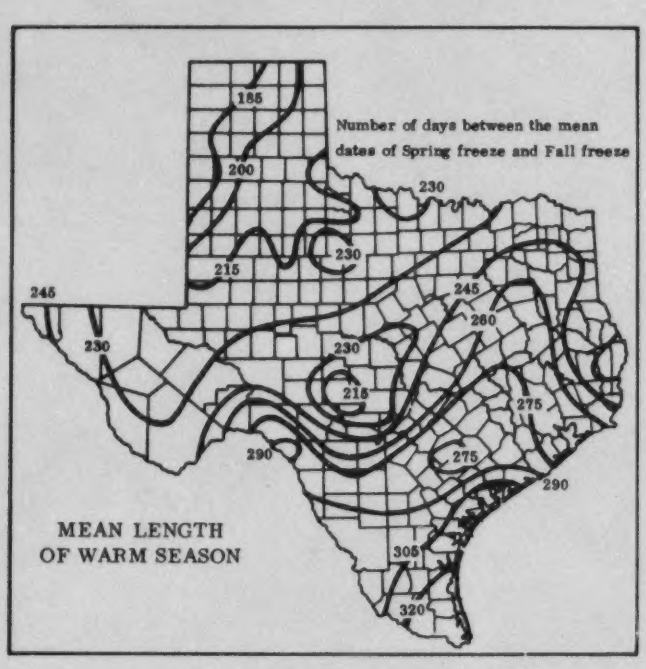
Too much water prevents or retards bacterial growth. Water and temperature also have the effect of swelling and contracting soil particles.

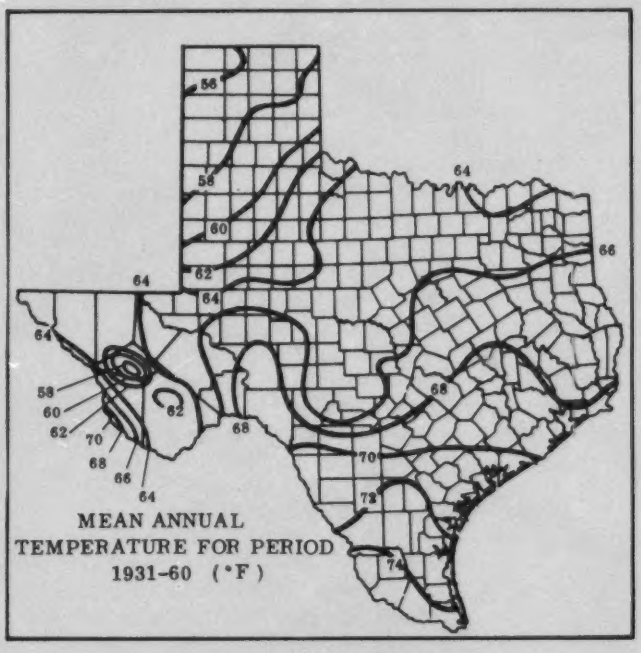
From the preceding, it is apparent that rainfall and temperature have both direct and indirect effects or soil formation.

The Texas climate varies from humid (wet) to arid (dry) and from temperate (mild) to subtropical. Various regions of the State are subject to sudden changes in the weather and to occasional events such as hail, torrential rains with flooding, tornadoes, freezes, hurricanes, and drouths. Sunshine is also abundant, ranging across the State from east to west. Relative humidity (east to west) at 6:00 p.m. commonly ranges from about 70 percent to less than 30 percent.

Temperature and humidity affect evaporation. Much of Texas has warm temperature and low relative humidity a large part of the year. Drouths are common in nearly every part of Texas, especially in the summer.

Soils, native vegetation, and land use reflect climatic variation in Texas.





B. Native Vegetation and Organisms

Vegetation and various organisms such as insects, "insect-type" creatures, animals, and man exert considerable influence upon the formation of a soil.

Certain types of soil bacteria and fungi aid in soil formation by causing decay or breakdown of the plant and animal residues in the soil. From these processes, carbon dioxide and other compounds essential to soil formation are released. Without soil organisms, organic materials would not decay.

Numerous insects, "insect-like" creatures, and animals contribute to the formation of soil by mixing the various soil materials. For example, earthworms absorb and digest certain soil substances which aid in decomposition. All such dead organisms add to soil organic matter.

Man and his civilized mode of living influence soil formation. For example, cultivation changes the surface layer, which influences soil-forming processes. The clearing of land removes native plant life, and thus destroys its natural effects on soil formation.

C. Weathering

Weathering processes are involved in soil formation in accordance with time or age, along with other soil-forming processes. The two major processes that are involved in the weathering of soils are: chemical and physical.

Chemical weathering is the result of the chemical reactions of water, oxygen, carbon dioxide, and other substances which act upon the soil materials (rocks, minerals, organic matter, etc.).

For example, the leaching action of water hastens the weathering process by the removal of soluble materials such as halite (rock salt).

$$\underset{\text{halite}}{NaCl} \longrightarrow \underset{\text{sodium ion}}{Na^{+}} + \underset{\text{chlorine ion}}{Cl^{-}}$$

Physical weathering refers to mechanical forces caused by temperature changes such as heating and cooling, freezing, and thawing. As these chemical and physical processes occur, rock, minerals, organic matter, and other soil-forming materials are broken into smaller and smaller particles until, finally, soil is made.

Soils at different stages of weathering will differ widely; for weathering causes soils to develop, mature, and age much as people do. Soils, like people, develop rapidly durirg their youth.

Plant nutrients are quickly released from the minerals, plant growth increases, and organic matter accumulates. Soils then age more slowly as they continue to weather.

Eventually nutrients in the soil are depleted. Water moving through the soil leaches away many soluble portions. At this stage many soils are acid because the limestone in them originally is gone. As this supply of nutrients in the soil decreases, the amount of plant growth is reduced to the point that the organic matter decomposes faster than it is produced.

In permeable soils the fine clay particles tend to move downward from the surface soil into the subsoil during the weathering process. This movement, together with further breakdown of the rock material, accounts for the fact that many soil types have a higher percentage of clay in the subsoil than in the surface soil.

As soils go through the more advanced stages of weathering, they slowly decline to lower and lower levels of production. These soil changes, of course, take place over long periods of time-thousands or even tens of thousands of years.

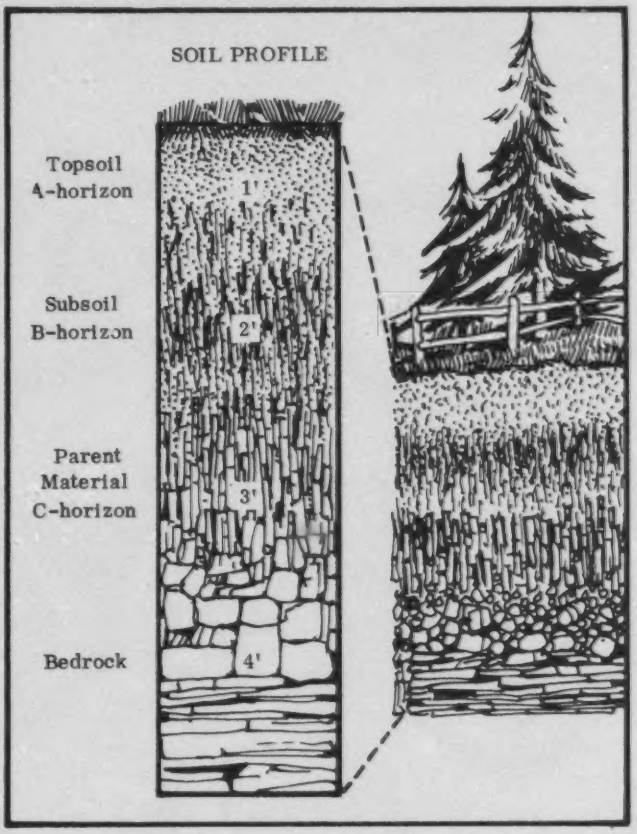
D. Parent Material

Parent soil material is the unconsolidated mass of material from which a soil develops. Parent materials comprise the "C" layer of the soil profile which is located over earth bedrock. These materials are rocks, other minerals, and sometimes peat.

Parent materials are deposited in several different ways-some are residual; others are transported. The latter includes materials that are transported, or moved, by water; marine deposits that are transported by seas; alluvial deposits that are transported by streams, and lacustrine deposits that are laid down by lakes. Other deposited parent materials are transported by wind (loess deposits), gravity (colluvial deposits), and ice (glacial deposits).

The kind of parent material from which a soil is formed influences the many characteristics of that soil. Two important soil properties associated with parent materials are natural fertility and texture.

For example, shale and slate materials produce soils that are high in clay content; sandstone gives rise to soils that are sandy; limestone produces soils that are somewhat shallow; basalts and diorites produce deep soils that are rich in bases-alkaline; and so on.



E. Topography

Slope and drainage affect soil formation both directly and indirectly. On a steep slope, for example, the effect is direct, i.e., loose material is moved downward by runoff water and gravity.

This movement not only breaks up soil materials and adds them to the lower levels, but it exposes subsoil materials along the upper slopes. Also, the movement of soil materials has a pulverizing effect on the material being moved as well as on that left behind.

Slope affects the distribution of water that falls on the earth's surface. For example, runoff on steeper slopes reduces the amount of "percolation" of water (downward and upward movement) through the soil.

This is an important factor in the formation of soil profiles, since small particles in solution

move down with the water. Slope and drainage are closely related. Soils that develop on level land tend to be poorly drained. The most productive soils are usually on level to gently-rolling slopes.

Drainage (or lack of it) affects the water table in a particular field or area. The water table, in turn, has a direct bearing on soil formation, especially where it is near the surface.

When a soil is saturated with water, little or no air can penetrate it, and the lack of air reduces the action of fungi, bacteria, and other soil-forming reactions in the soil.

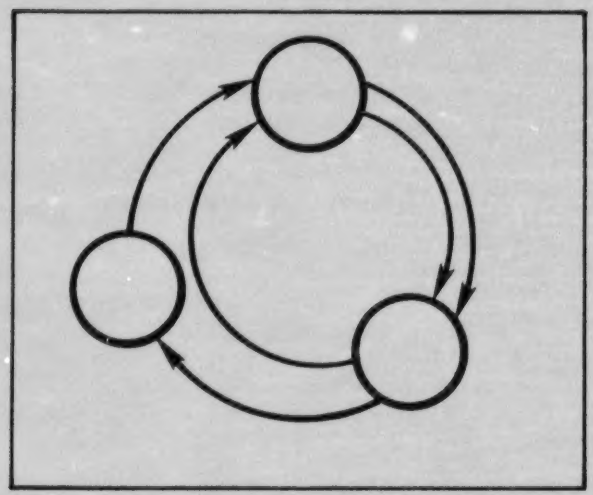
A "wet" soil is, therefore, a "slow-forming" soil and is usually low in productivity. Because of this lack of air, undecomposed organic matter will accumulate in a wet soil. Poor drainage, accompanied by free water in the soil, thus reduces or retards plant growth and, therefore, affects soil formation.

GLOSSARY OF TERMS

1. "C" Layer - Soils are composed of one or more layers. The "A" layer is the surface, the "B" layer is the subsoil, and the "C" layer is the underlying parent material above bedrock.
2. Leaching - The removal of soluble materials from the soil by the action of water passing through the soil.
3. Percolation - The downward movement of water through the soil in response to the pull of gravity.
4. Permeable - Refers to the ability of soil to be penetrated by air and water.
5. Residual - Refers to the soils formed in materials from bedrock that have not been moved or transported from the original location.

SELECTED STUDENT ACTIVITIES

1. Complete the diagram below with statements which tell the relationships between soil, plants, and animals.



2. What percent of the total land surface area (171.5 million acres) in Texas is used for the following?

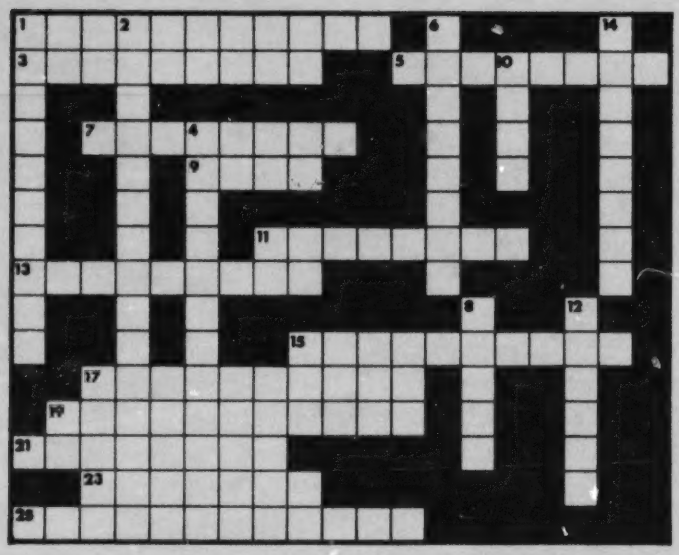
Cropland	_____%
Forest	_____%
Range and Pasture	_____%
Recreation	_____%

3. What are the five "soil forming factors"?
   a.
   b.
   c.
   d.
   e.
4. Realizing that the amount of rainfall and the temperature in a given locality affect the soil, look at the illustrations of Texas to determine data for the county in which you are living.

Average annual rainfall	_____ (inches)
Average annual temperature	_____ (°F)
Average length of warm season	_____ (days)

5. What are the two major processes that are involved in the weathering of soils? Briefly explain these.
   a.
   b.
6. What is the difference between residual and transported parent materials?

7. Crossword Puzzle



Across:

1. A climatic factor which affects rate of weathering.
3. Soil _ _ _ _ _ _ _ _ _ consist of bacteria, fungi, and "insect type" creatures.
5. Mechanical forces caused by temperature changes which affect weathering are classified as _ _ _ _ _ _ _ _.
7. Loss of soil nutrients resulting from heavy rainfall on sandy type soils.
9. General term denoting the soil surface.
11. That portion of the land devoted to the production of crops.
13. Relates to movement of air and water in the surface soil and subsoil.
15. Non-agricultural productive use of land.
17. Process involved in soil formation resulting from the breakdown of soil materials.
19. Downward and upward movement of water in the soil.
21. Soil formations resulting from the breakdown of parent materials are said to be _ _ _ _ _ _ _.

Across: (continued)

23. Accounts for about 14 million acres of the total land area in Texas.
25. Factors affecting soil formation are referred to as _ _ _ _-_ _ _ _ _ _ factors.

Down:

1. Slope and drainage constitute a part of the soil's _ _ _ _ _ _ _ _ _ _.
2. Third layer of soil in a soil profile.
4. Rainfall and temperature affect the _ _ _ _ _ _ _ of a soil.
6. A weathering process resulting from the reaction of water, oxygen, carbon dioxide, and other substances.
8. Accounts for about 86 million acres of the total land area in Texas.
10. Contains food for plants.
12. Accounts for approximately 23 million acres mostly in East Texas.
14. Occurs in greater amounts in the eastern part of the state.

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138

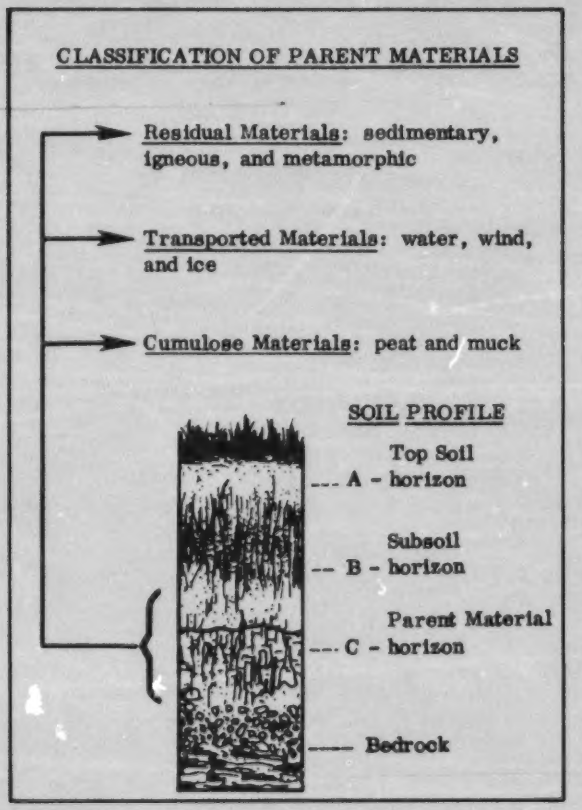
COMPONENTS OF SOIL AND ITS PROPERTIES

I. SOIL ORIGIN

It is the custom of agronomists to refer to the origin of the parent material* of soils when referring to the nature of the soil. It is desirable to have an understanding of the origin and classification of parent material before considering the origin and classification of soils.

Soil parent materials may be referred to as a geological formation. It is a layer of material varying from a few feet in thickness to many feet. Wherever a geological formation is exposed at the earth's surface, either there is soil formation taking place or a soil has already developed from the exposed material. Productive soils develop only from minerals and rocks which are plentifully supplied with all essential elements needed to support plant life.

Parent materials from which soils are formed may be classified as residual, transported, or cumulose.



*Underlined words are defined in the Glossary of Terms.

A. Residual Materials

Residual materials are those which have developed from the underlying rocks and minerals. Most rock formations at the earth's surface are sedimentary. Other rock formations are classified as igneous or metamorphic.

Examples of residual materials are those which have weathered from limestone, sandstones, shales and slates, and many crystalline rocks such as granites and basalts.

B. Transported Materials

1. Materials that have been transported by water are classified as alluvial, lacustrine, or marine.
   a. Alluvial materials are sediments which have been transported by flowing water, such as small streams or large rivers.
   b. Lacustrine materials are those which have eroded into lakes from surrounding uplands. These materials were deposited in fresh-water lakes during glacial times. The greatest lacustrine deposits in the United States are bordering the Great Lakes.
   c. Marine materials are those which were formed as sediments and were washed out to sea by rivers and later lifted above sea level. The principal marine sediments occur along the Gulf Coast and the Atlantic Coast.
2. Materials transported by wind are classified as either eolian deposits or loess deposits.
   a. Eolian deposits are sand dunes or deposits from present day dust storms.
   b. Loess deposits are soil materials that were deposited following the last glacial period. Loessial soil materials are silt-loam in texture and are found mostly in the Mississippi Valley.
3. Materials transported by ice are commonly classified into three topography types namely, moraines, till plains, and outwash plains. Ice deposits, according to geologists, were formed four times during our geologic history. The climate become so cold that a huge sheet of ice, one mile thick in places, moved south from Canada and covered the United States. As the ice moved southward, it ground the rocks beneath, gouged the valleys,

scoured the loose materials off the hills, and mixed them together. This mixture, called glacial till, contained fine particles, stones, and sometimes huge boulders. This process of soil formation took place over a period of hundreds of years. Unlike residual soils, the glacial till does not contain the underlying rocks.

4. Materials transported by gravity exist to some extent at the base of all slopes. The soil materials that moved to the base of the slope in response to gravity is called colluvial material. It is more noticeable in mountainous topography where rock slides, slips, and avalanches are common.

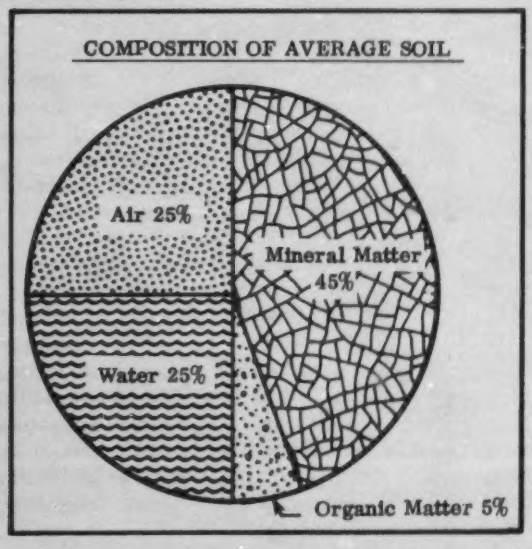
C. Cumulose Material (Organic)-Peat and Muck

Cumulose materials are the plant residues that have been developed in shallow lakes and are recognized as peat and muck. Peat is the term used for material when the plants are recognizable. Muck describes the material when plants have decayed beyond recognition.

Parent materials of soil are constantly being developed today as rocks and minerals are weathered by both physical and chemical processes. Physical weathering processes include constant temperature changes, climatic conditions, rainfall, erosion, the action of animals, plants, and man. Chemical processes include such factors as oxidation, reduction, solution, hydrolysis, hydration, and carbonation.

II. THE GENERAL COMPONENTS OF SOILS

A. It should be emphasized at this point that soils develop from parent material by processes of soil formation that differ from processes of rock weathering, which produce parent material. As a soil is developed from the parent material certain changes take place which distinguish the various soil layers.



B. Soils are made of living and non-living materials which are of three forms; solids, liquids, and gases. The organic matter and minerals in the soil are the solid materials; and air and water, which move through the soil pores, are the gases and liquids. Approximately 45 to 49% of the soil (by volume) is mineral, 1 to 5 percent is organic matter, and 50% is water and air.

1. The mineral in the soil is inorganic and contains approximately sixty-four elements, which should be available to the growing plants. Some of the elements are of minor importance, but fourteen are considered to be of prime importance. Some of the important elements are nitrogen, phosphorus, potassium, carbon, oxygen, sulfur, calcium, iron, and chlorine. The mineral elements in the soil, with the exception of those introduced by man, come from rocks and decayed plants and animals.
2. Organic matter, another of the earth's solids, is formed from decomposed plants and animals such as plant roots, crop residue, green manure crops, and stable manure. Soils high in organic matter also are high in soil microorganisms, which affect the rate of decomposition of plants. Microorganisms obtain their energy, as do animals, by oxidizing organic matter. The amount of organic matter, often called humus, in the soil to some extent depends on climate and drainage; the soils in warmer climates usually have less organic matter.

The physical features, called tilth, of the soil are affected by the amount of organic matter in the soil. A high organic matter content in the soil will give the following benefits:

a. Makes the soil porous
b. Supplies nitrogen to the growing plant
c. It helps hold water in the soil so that growing plants are protected against droughts.
d. It aids in managing the soil moisture content.
e. Furnishes food for soil organisms
f. Serves as a store house for mineral nutrients
g. Minimizes leaching
h. Serves as a source of nitrogen and growth promoting substances
i. Stabilizes the soil structure

Soil water and air, the liquids and gases in the soil, are necessary for plant growth. The soil absorbs a great amount of water during rains, and water that is not absorbed by the soil drains away unless measures are taken to conserve it. The amount of moisture and air in the soil varies depending on climatic conditions. As the soil absorbs more water, there is less air in the soil; and as the soil dries out, air replaces the moisture. Plants receiving excessive water for too

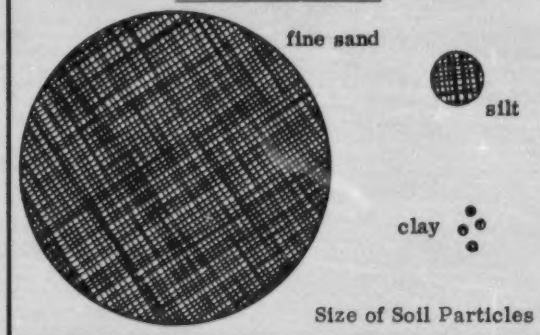
140

long a period of time will die because of a lack of oxygen. Soil in good physical condition will hold more water and air than poorer conditioned soils.

III. THE SIZE OF SOIL PARTICLES

A mechanical analysis is used to determine the percentages of different size groups of soil particles. These groups of soil particles (or soil separates) are determined by diameter ranges and are classed from coarse to fine.

THE RELATIVE SIZES OF SAND, SILT, AND CLAY PARTICLES



Size of Soil Particles

Name	Size, Diameter in Millimeters
fine gravel	2 - 1
coarse sand	1.00 - 0.50
medium sand	0.50 - 0.25
fine sand	0.25 - 0.10
very fine sand	0.10 - 0.05
silt	0.05 - 0.002
clay	less than 0.002

The size of soil particles is important because it affects the water holding capacity and workability of the soil. Gravel, sand, silt, and clay are the four mineral particles found in the soil.

A. Gravel and sand, the larger particles, can be seen with the eye; soils with a high percent of gravel and sand are infertile because they do not provide nutrients to the growing plants. These soils dry out quickly and are droughty.

B. Silt particles are between those of sand and clay in size, and until they have weathered to fine-sized particles, they provide few nutrients for the growing plant. After rains, soils with a high percent of silt tend to run together and form a soil crust, and they erode very easily.

C. Clay, the smallest of the soil particles, holds soil nutrients, determines the acidity of the soil, and holds more moisture than either sand or silt. Clay particles are microscopic in size; their expansion and contraction depend on the amount of moisture present. In the presence of water, clay particles are separated by a film of moisture; as the moisture evaporates and the soil becomes dry, the soil contracts and leaves a crack in the ground. Clay soils dry out slowly and become cloddy unless properly managed. A good mixture of soil should contain sand, silt, and clay.

IV. MAJOR FACTORS USED TO DESCRIBE SOIL DIFFERENCES

Although soils in general are made up of the same components, they differ in their properties or characteristics; and these differences affect or determine the way in which they should be managed. Soils differ in their color, texture, structure, consistence, and fertility and productivity. Even though many years of proper soil management are required to change the characteristics of the soil, farmers can make considerable improvements in the structure, fertility, and productivity of the soil.

A. Soil Color

Color is one of the most easily recognized soil characteristics and is very apparent in a soil profile. The surface colors of soil are classified as dark, moderately dark, light, or very light; and the subsoil colors are classified as dull, mottled, or bright. The surface soil has a much darker color than subsoils because it usually contains more organic matter.

The color of the soil is usually a good indication of the amount of organic matter, the amount of moisture, and the texture of the soil. The dark color of topsoil usually indicates presence of organic matter. Light-colored soils are generally low in organic matter content, or high in sand particles, or contain iron or manganese oxide.

Soil drainage, which is the movement of water through and off the soil, affects the color of the soil and will determine the kinds of crops that can be planted. The color of a well-drained soil is red or brown, fair-drained soils are yellow, and poorly-drained soils are gray. A mottled subsoil indicates that the soil is saturated with water at certain times of the year and dry at other times.

B. Soil Texture

Soil texture refers to the size of the individual soil particles, and is thought of as the fineness or coarseness of soil particles, determined by the percentages of sand, silt, and clay in the surface layer of the soil. Most soils contain a mixture of sand, silt, and clay; it would be unusual to find a soil made up of only one of these. Soil textural classes denote the average or combined effect of the soil particle sizes in a given sample. In the laboratory, soil texture is determined by a mechanical process of separating the soil into groups of grain sizes.

141

SOIL TEXTURAL CLASSES

SAND - Dry: Loose and single grained; feels gritty. Moist: Will form very easily-crumbled ball. Sand--85-100%, Silt--0-15%, Clay--0-10%.

LOAMY SAND - Dry: Silt and clay may mask sand; feels loose, gritty. Moist: Feels gritty; forms easily-crumbled ball; stains fingers slightly. Sand--70-90%, Silt--0-30%, Clay--0-15%.

SANDY LOAM - Dry: Clods easily broken; sand can be seen and felt. Moist: Moderately gritty; forms ball that can stand careful handling; definitely stains fingers. Sand--43-85%, Silt--0-50%, Clay--0-20%.

LOAM - Dry: Clods moderately difficult to break; mellow, somewhat gritty. Moist: Neither very gritty nor very smooth; forms a firm ball; stains fingers. Sand--23-52%, Silt--28-50%, Clay--7-27%.

SILT LOAM - Dry: Clods difficult to break; when pulverized feels smooth, soft and floury, shows fingerprints. Moist: Has smooth or slick "buttery" or "velvety" feel; stains fingers. Sand--0-50%, Silt--50-88%, Clay--0-27%.

CLAY LOAM - Dry: Clods very difficult to break with fingers. Moist: Has slightly gritty feel; stains fingers; ribbons fairly well. Sand--20-45%, Silt--15-33%, Clay--27-40%.

SILTY CLAY LOAM - Same as above but very smooth. Sand--0-20%, Silt--40-73%, Clay--27-40%.

SANDY CLAY LOAM - Same as for clay loam. Sand--45-80%, Silt--0-28%, Clay--20-35%.

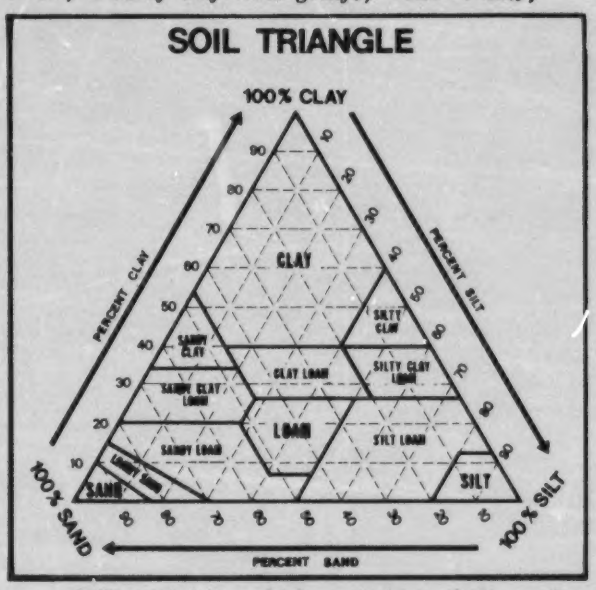
CLAY - Dry: Clods cannot be broken with fingers without extreme pressure. Moist: Quite plastic and usually sticky when wet; stains fingers. (A silty clay feels smooth; a sandy clay feels gritty.) Sand--0-45%, Silt--0-40%, Clay--40-100%.

Each of the soil particles has a distinctive feel; with a knowledge of soil textural classes and some experience, students should be able to determine the texture of the soil. The student should work some moist soil in his hand. Sand particles will feel gritty and coarse and will mold; however, the molded sand may fall apart when the hand is opened. Silt particles are sticky and gummy in moist soils and floury in dry soils. As moist silt particles are worked between the thumb and index finger, they will stick together and fall off the finger in large pieces. Clay particles are very sticky. When worked between the thumb and index finger, clay will form a leaf of soil up to one inch in length before it falls off the finger.

For convenience in determining the textural name of a soil from the mechanical analysis, an equilateral triangle has been adapted.

The textural triangle gives the percent of sand, silt, and clay in each of the textural classes.

Because of their large size, sand and large silt particles have a low specific surface, or a surface area per unit mass. Since most of the important chemical and physical-chemical reactions in soils take place at the particle surface, the amount of surface area affects the ability of soils to react to chemicals. Soils with a high percentage of large particles lack plasticity and cannot retain large amounts of water or nutrients. However, the organic matter content of these soils can be increased, thus increasing the amount of nutrients and moisture available to plants.



Soils containing a high percentage of clay or fine silt particles have greater chemical activity which is necessary to maintain good soil structure and to form soil aggregates.

C. Soil Structure

Soil structure, the arrangement of soil particles into various sizes and shapes, is important because it affects the soil tilth and management decisions made by the farmer. The particles in different type soils stick together differently and give the soil particles a different shape. The farmer can control the soil structure through his method of cultivation, time of cultivation, and by

regulating the amount of organic matter lime. Good farmers try to keep their soils in a good state of tilth at all times.

Soils with a good structure contain a lot of crumbs or aggregates, which indicate good tilth. Good structured soil permits deeper root penetration and a greater area from which the plant can secure nutrients.

An example of two different types of soil structure could be obtained by taking a soil sample from an area with a dense, heavy growth of grass and taking a sample from a field that has been in continuous cultivation. The sample taken from the grassy area will be grainy and will contain a large amount of aggregates, while the sample taken from the field will be firm, hard, and will lack aggregates or crumbs.

Categories For Classifying Structural Aggregates of Soils

Soils scientists classify structural aggregates of soils into three main categories, based upon their shape, size, and strength.

1. Type of soil structure

   The main soil structure types determined by the shape and arrangement of aggregates are granular, prismatic, blocky, and platy. Evidence of the soil structure types can usually be observed when a clod of soil is broken. If the cracks or lines of cleavage are mostly vertical, the soil has a prismatic or columnar structure; when cleavage is mostly horizontal, a platy structure exists; and when the cracks or cleavage are about equal, the soil has a blocky or granular structure.

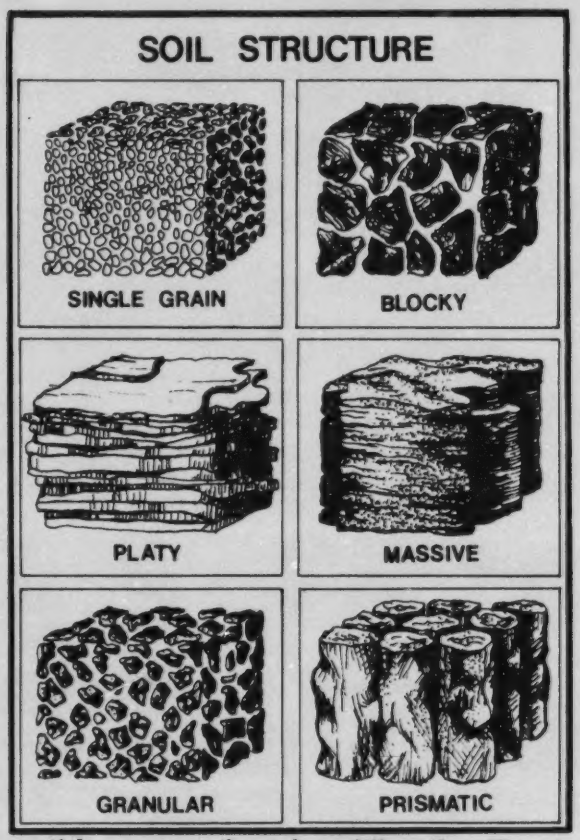
2. Class of soil structure

   Class of soil structure is determined by the size of the soil aggregates, and they are commonly classed as coarse, medium, or fine. Size of soil aggregates varies with their shapes.

3. Grade of soil structure

   Grade of soil structure is determined by the strength of soil aggregates. Strength of the soil aggregate is measured by its resistance to crushing. Soils are considered to be structureless when the particles of coarse soil fail to cling together, or when fine soil breaks into large cementlike clods. Other descriptive grades of soil structure are weak, friable, and firm.

In order to describe soil structure, scientists have named the shape of each kind of structure in which the particles arrange themselves differently. The six most common types of soil structure are single grain, granular, blocky, prismatic, platy, and massive.



Soil structure influences many important functions of the soil, such as the infiltration rate of water. Soils with a single grain or granular structure possess a rapid rate; soils with a blocky or prismatic structure have a slow rate of infiltration.

Since soil structure is important to soil management, the farmer or student should become familiar with the maintenance of good structure and the formation of aggregates or crumbs. Soil particles are grouped into aggregates by the action of complex sugars. While one part of the sugar arranges the soil particles loosely into clusters, another part is binding the particles firmly into aggregates. Before soil particles can be bound into aggregates, they must be grouped into loose clusters.

Flocculation, the first step in forming a soil aggregate, is caused by nature. Flocculation pulls the clay particles close together so that they are cemented with gum, which is made from soil sugars. The second step in aggregate formation is the binding of the clay particles in the flocs into aggregates.

The removal of plant cover from soil destroys aggregation and sugars that bind the particles. The longer the soil is without a cover, the more breakdown there is in the aggregate. As plants cover the soil, aggregates start to rebuild and the breakdown stops.

D. Soil Consistence

Consistence refers to the cohesiveness of soil or its resistance to rupture or deformation. Soil consistence and structure are interrelated in that structure deals with the shape, size, and distinctness of natural aggregates, while consistence refers to the force required to rupture soil material.

Consistence may be described under moisture conditions of wet, moist, or dry soil. When the soil material is wet, consistence is described by its stickiness or plasticity. Consistence when soil is moist is characterized by its tendency to break into smaller masses, but its ability to cohere again when pressed together. The consistence of soil material when dry is characterized by brittleness, maximum resistance to pressure, and inability of crushed material to cohere again when pressed together.

E. Soil Fertility and Productivity

Soil fertility is the ability of the soil to provide nutrients for plant growth. Regardless of the level of soil fertility, plant food must be returned to the soil if the soil is to stay fertile. As plant nutrients in soils decrease, the plant growth declines.

The productivity of a soil is the present capability of that soil for producing a specified plant or sequence of plants, under a defined set of management practices. It is measured in terms of outputs, or harvests, in relation to production inputs-fertilizer, etc., for a specific kind of soil.

The capability of a soil under a particular system of management is dependent upon such factors as the soil's natural fertility, organic matter content, texture, structure, and climate.

GLOSSARY OF TERMS

1. Cleavage - The tendency of crystalline rocks or mineral particles to split along thin parallel lines into thin sheets. As applied to rocks these thin sheets may form the bedrock planes, as in slate.

2. Floc - A cluster of soil.

3. Flocculation - The process by which suspended colloidal or very fine particles are assembled into larger masses or floccules which eventually settle out of suspension.

4. Organic Matter - The plant or animal residue contained in the soil at varying stages of decomposition.

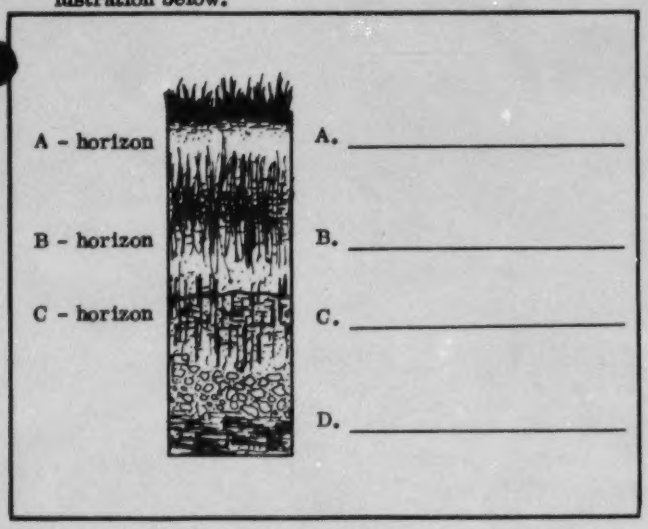
5. Parent Material - The unconsolidated mass of mineral or rock from which the upper layers of the soil profile are formed.

6. Soil Profile - A vertical section of the soil from the surface through all its horizons, including C horizons.

7. Soil Tilth - The condition of the soil structure. Soils that have good structure are easy to work and have good tilth.

SELECTED STUDENT ACTIVITIES

1. Identify the layers of a soil profile as shown on the illustration below.



2. What are the three groups in which soil parent materials are classified?
   a.
   b.
   c.

3. List the four general components of an average soil and indicate the percentage of each part.

a.		_____%
b.		_____%
c.		_____%
d.		_____%
	Total	100%

4. Why is the size of soil particles important?

5. What are the characteristics or properties by which soils differ?
   a. d.
   b. e.
   c. f.

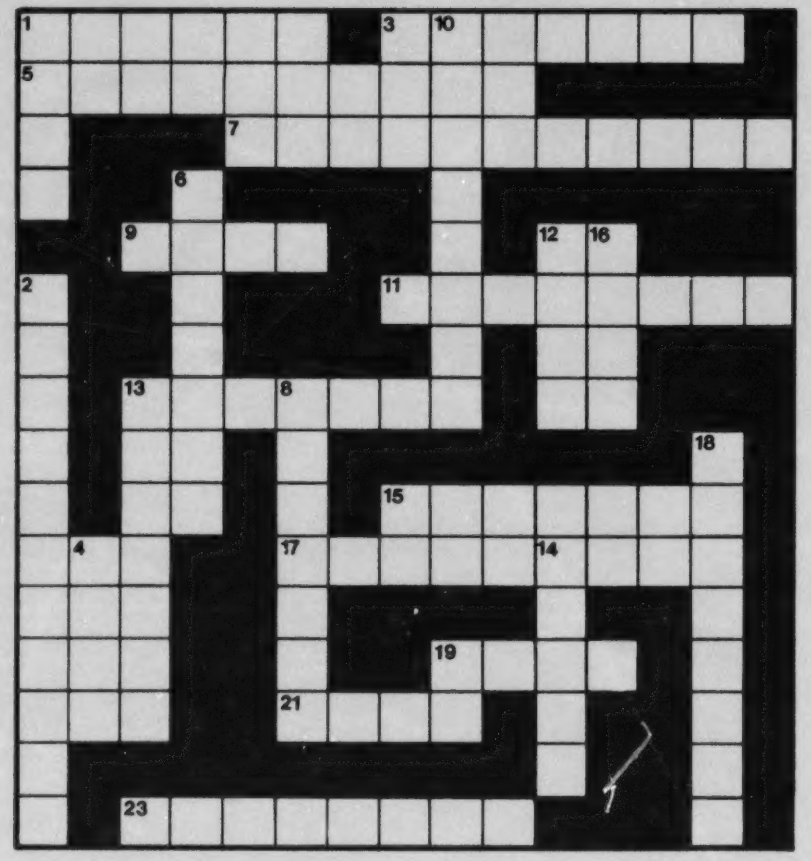
6. Complete the following statements which relate to soil differences by circling the best suited response.
   a. The darker color of topsoil usually indicates the (absence, presence) of organic matter.
   b. The color of a well drained soil is more apt to be (brown, yellow, gray).
   c. Soil texture is determined by the percentages of (sand, silt, clay,) in a soil.
   d. The arrangement of soil particles in various sizes and shapes determines soil (depth, structure, color).
   e. Soil (consistence, productivity) refers to the cohesiveness of soil or its resistance to rupture or deformation.

7. Assume that you had three one-gallon containers filled with sand, silt, and clay respectively. Which of these containers will hold the most moisture?

8. Looking at the soil textural triangle, which of the soil classes has about equal amounts of sand, clay, and silt?

9. What important function of soils does soil structure influence?

10. Crossword Puzzle



Across:

1. Organic matter and mineral portion of soils
3. Exposed vertical section of soil showing distinct layers
5. Soil particles of various shapes and sizes
7. Soils are_____by water, wind, and ice
9. Soil materials containing recognizable plants
11. Peat and muck materials
13. A-horizon
15. Inorganic elements in soil
17. Arrangement of soil particles
19. Floury feeling soil particles
21. A soil mixture having about equal parts of sand, silt, and clay
23. A type of soil structure which has a rapid infiltration rate of water

Down:

1. Gritty soil material
2. Refers to the cohesiveness of soil
4. Soil texture having sticky feel
6. Bottom layer in a soil profile
8. B-horizon
10. Soil materials which have developed from underlying rocks and minerals
12. Soil material when plants have decayed beyond recognition
14. Condition of the soil structure
16. A cluster of soil
18. Tendency of soil mineral particles to split into thin sheets

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SOIL CLASSIFICATION AND SAMPLING

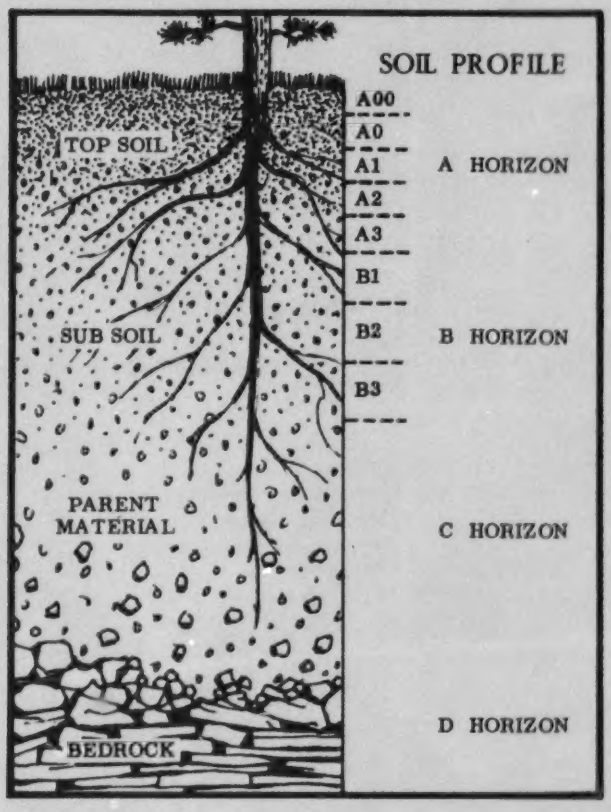
I. SOIL CLASSIFICATION

In order for soil scientists to study soils, there had to be some system of soil classification and identification. The scientist recognizes a soil by its features, the same way an individual is recognized.

Classfication consists of an orderly grouping of defined kinds of soils into classes in a system designed to make it easier to remember their characteristics. The purpose of the classification of soils is to place them into suitable categories to study and interpret their interrelationships or inherent problems. Land use and other principles of treatment can then be determined and applied to each class of land.

A. Identifying Soil Characteristics on a Soil Profile

Since the features of the soil are found in the soil profile, one must be familiar with the soil profile in order to classify soils.



A soil profile is a vertical section of the soil extending down through all of its horizons-"A," or topsoil; "B," or subsoil; and "C," or parent materials, which is the layer just above solid-earth bedrock. These horizons often merge with one another, and therefore may not be easily identified. The horizons of a particular soil vary in one or more properties such as texture, color, structure, consistency, porosity, and reaction. By studying these variations and properties, it is possible to identify soils.

The depth of each horizon in a soil profile varies in accordance with the several factors which originally influenced its formation. Some are thick, some thin, varying from less than an inch to several feet.

Soil horizons vary in thickness and generally are merged with one another; therefore, the horizons usually lack sharp boundaries. Most soil profiles include three master horizons, identified by the letters A, B, and C; however, some soils lack a B horizon and are said to have AC profiles. Eroded soils may not have an A horizon, and in some cases the B horizon may have eroded away.

1. "A" HORIZON or TOPSOIL

The soil on the surface makes up this horizon, unless this layer has been completely eroded away. The "A" horizon is the soil layer where life is most abundant in the form of plant roots, bacteria, fungi, and insects. It is the layer usually cultivated for crops.

All of the master horizons may be subdivided in the scientific study of soils. Such subdivisions are identified by the proper letter plus a subscript number, thus: A_1, A_2, A_3, etc. The subdivisions of master horizons provide clues to the processes of soil formation and are important to the use and management of the soil.

The subdivisions of the "A" horizon are as follows:

A_{00}—Loose leaves and organic debris,* largely undecomposed.
A_0—Organic debris partially decomposed or matted.

*Underlined terms are defined in the "Glossary of Terms."

A_1—A dark-colored horizon with a high content of organic matter mixed with mineral matter.

A_2—A light-colored horizon of maximum eluviation. Prominent in podzolic soils.

A_3—Transitional to B, but more like A than B. Sometimes absent.

2. "B" HORIZON or SUBSOIL

The "B" horizon is the layer of soil lying just beneath the "A" horizon and is referred to as the subsoil. It contains more clay and less organic matter than the topsoil.

The "B" horizon forms partly by the downward movement of the finer soil particles during the percolation of soil water. Organisms and plant residues have very little influence on the formation of the "B" horizon. Neither does cultivation, except where there is some mixing of topsoil with the "B" horizon. Therefore, the characteristics of the subsoils are usually an accurate index to their true nature and origin.

The subdivisions of the "B" horizon are as follows:

B_1—Transitional to B, but more like B than A. Sometimes absent.

B_2—Maximum accumulation of silicate clay materials or of iron and organic matter; maximum development of blocky or prismatic structure; or both.

B_3—Transitional to C.

The combined "A" and "B" horizons, the major part of a soil profile, are called the solum or true soil. This is the area that supports plant growth.

3. "C" HORIZON or PARENT MATERIAL

The "C" horizon is the layer of loose parent material lying between the "B" horizon and earth bedrock. Parent materials are important not only because they affect the formation of subsoils above them, but because they are directly associated with the texture and natural fertility of any soil. The "C" horizon has less living matter than overlying ones and is therefore lower in organic matter. It is commonly lighter in color than "A" and "B" horizons.

The subdivisions of the "C" horizon are as follows:

G—Horizon G for intensely gleyed layers, as in hydromorphic soils.

Cca and Ccs—The weathered parent material. These horizons are layers of accumulated calcium carbonate and calcium sulfate found in some soils.

4. "D" HORIZON or BEDROCK

The "C" horizon is any stratum underneath the soil, such as hard rock or layers of clay or sand, that are not parent material, but which may have significance to the overlying soil.

B. Classifying Soils

People have always classified soils by their colors, water holding capacity, or by some other characteristic, but this was not very specific or exact. To take advantage of soil research and to increase yields, soil scientists had to classify soils according to a scheme. The soil classification scheme being used at the present time is grouped as follows:

1. ORDER—The soil order is the highest and most general level of soil classification. At present, 10 soil orders are used. The orders reflect in a general way geographic distribution of soils similar in degree and kind of horizon development. ENTICOLS, for instance (found in a small area in West Texas), lack well defined genetic horizons, while ULTISOLS are weathered to an advanced stage and have horizons strongly contrasting in color.
2. SUBORDER—The suborder, a division of the soil order, groups soils which have common characteristics reflecting uniformity in the soil forming factors. For example, AQUALFS are seasonally wet ALFISOLS that are gray and mottled.
3. GREAT GROUP—The great group is a further subdivision of the suborder, and provides for grouping soils largely on the presence or absence of diagnostic horizons and their arrangement. For instance, MOLLISOLS that contain significant alluvial clay are called ARGIUSTOLLS.
4. SUBGROUP—At the subgroup level soils with properties typical of the great group are classified together.
5. FAMILY—Soils similar in texture below the surface layer and similar in clay mineralogy, temperature, and other properties are grouped in the same soil family. Houston Black clay is in the fine, montmorillonitic, thermic family of Udic Pellusterts.
6. SERIES—Soils essentially uniform in kind, thickness, and sequence of horizons and very similar physically, chemically, and mineralogically are called a soil series. This is the lowest category of formal soil classification. Houston Black is an example of a series name. The series name usually derives from the place where the soil was first found. There are approximately 8,000 soil series in the new classification system.
7. TEXTURAL CLASS—The textural class is determined by the percentage of sand, silt, and

clay in the surface layer of the soil. The surface texture is allowed to vary more than other properties.

8. TYPE—There are approximately 80,000 soil types in the United States, and the series name combined with the textural name is the soil type. An example of soil type would be Norfolk, fine, sandy loam.
9. PHASE—Phases are individual areas of soil types which have differences in slope, stoniness, and thickness due to erosion. For example, Pullman clay loam, 0-1 percent slopes is a soil phase.

An example of the scientific classification of a soil sample might be as follows:

ORDER	Alfisols
SUBORDER	Ustalfs
GREAT GROUP	Paleustalfs
SUBGROUP	Vertic Albaqualfs
FAMILY	Fine, Montmorillonitic
SERIES	Tabor
TEXTURAL CLASS	Fine Sandy Loam
TYPE	Tabor Fine Sandy Loam
PHASE	1-3 Percent Slopes

Differences among soil types occur even within the boundaries of small farms. Each soil type can be defined by a description of the typical profile, the allowable differences from that profile, and other features such as slope, stoniness, and physiographic position.

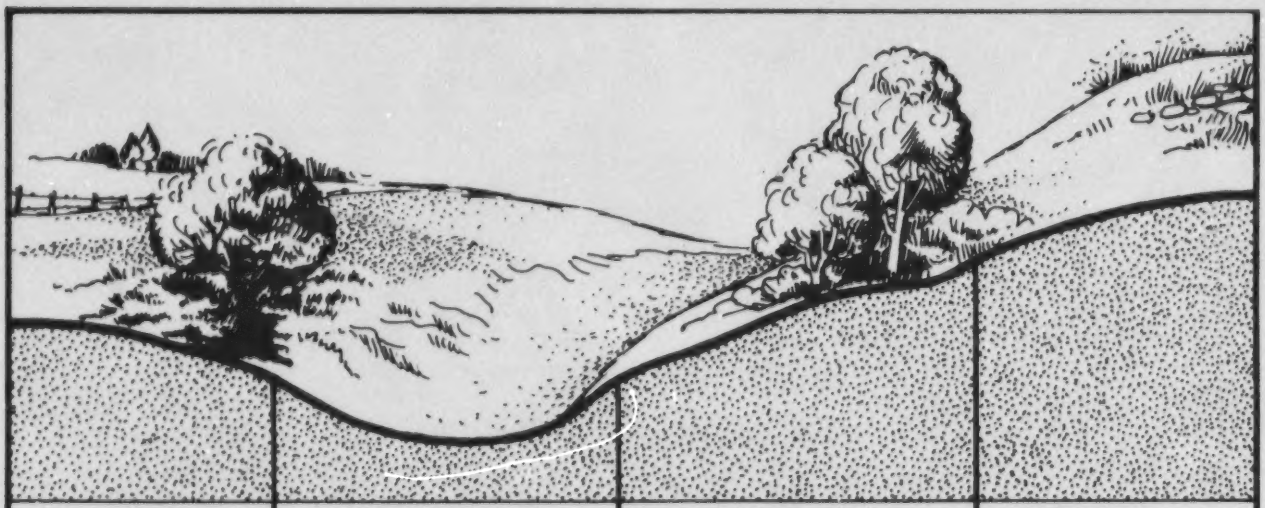
Similar soil types always occur in a definite geographic area and in the same formations. In other words, they always choose the same neighbors. The individual bodies of neighboring soil types within a farm fit together like the pieces of a jigsaw puzzle as shown in the illustration. However, soil types are not set apart as distinctly as the sketch suggests; they grade into one another without sharp boundaries between them. This is one reason why soil appears to be a continuous mantle over the land surface.

C. Making Soil Surveys

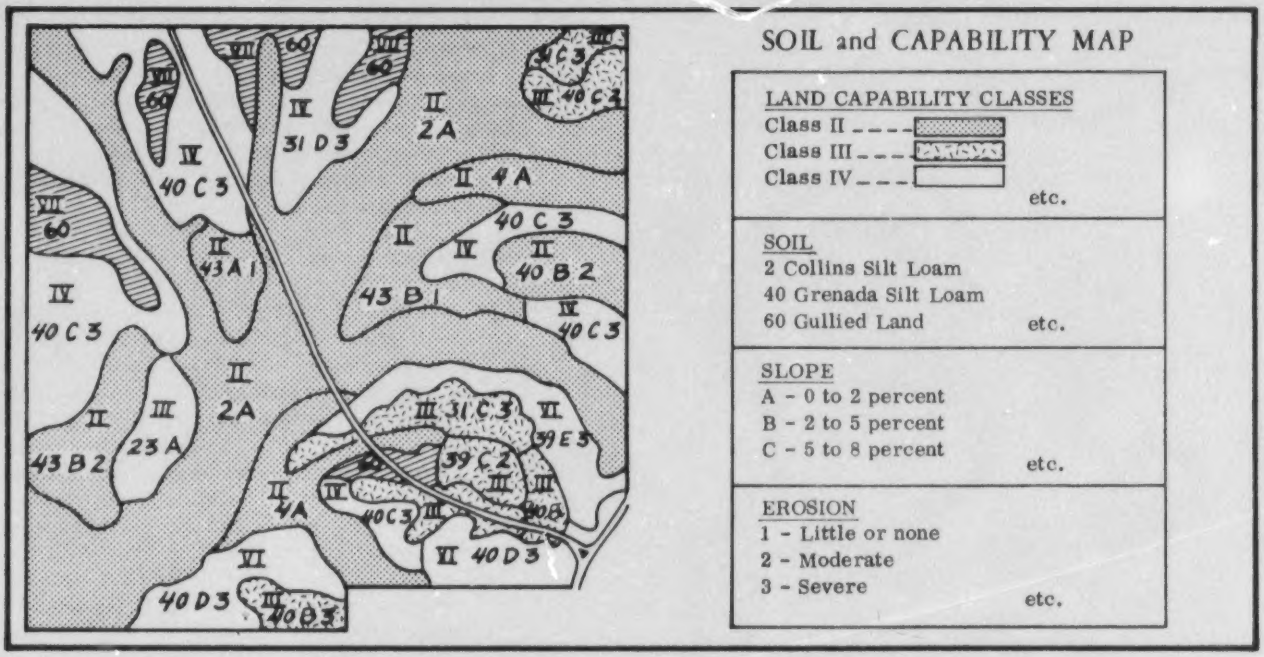
Soil classification and identification are important in order for farmers to make decisions necessary to secure maximum production. The information obtained by soil scientists in classifying and identifying various soils is recorded in a soil survey.

A soil survey is a map of a farm that designates the kinds and location of soils. It also gives a description of the soils along with suggestions as to their use and management.

Soil surveys should be made by an experienced person such as a local S.C.S. technician. The first step in making the survey is to secure an aerial map of the area to be surveyed. After a thorough study of the map, the technician takes soil samples and determines the texture, color, and thickness of each layer of soil in order to classify and identify the soils. To complete the survey, the technician draws lines on the aerial photograph to designate changes in soil. The soil map will also designate soil types, erosion, slope, and land capability classes. All of this information is necessary for proper soil management and maximum production.

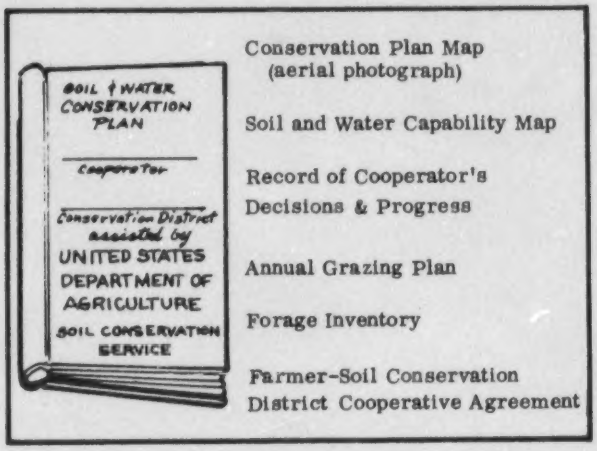


HOW SOIL TYPES FIT TOGETHER



D. Preparing Conservation Plans

In order for the landowner to derive the maximum benefit from a soil survey report, he should secure the services of the local Soil Conservation Service personnel to assist him in developing a soil and water conservation plan for his farm or ranch. The conservation plan consists of a plan map (aerial photograph) of the individual farm and a soil survey map. The conservation plan represents a cooperative agreement between the landowner and the Soil Conservation Service District. It reflects the landowner's decisions on how to use the land based on sound land use and economy of operations.


SOIL & WATER CONSERVATION PLAN
Cooperator
Conservation District assisted by
UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Conservation Plan Map (aerial photograph)
Soil and Water Capability Map
Record of Cooperator's Decisions & Progress
Annual Grazing Plan
Forage Inventory
Farmer-Soil Conservation District Cooperative Agreement

The conservation plan, after being completed, will serve as a guide for soil and water conservation improvements to be carried out by the landowner for several years. The Soil Conservation Service then provides technical assistance at no cost to the landowner for putting the plan into operation and in making needed changes in the plan.

II. SOIL SAMPLING

The soil in some respects is like people; it needs a periodic check up. It is through this periodic check up, along with good management practices, that the highest return on the investment in fertilizer and lime can be acquired. In order to know the proper amount of fertilizer and the lime the soil needs, the soil should be tested. The soil test will provide a scientific basis, rather than a haphazard hit-and-miss basis, for correct usage.

There are thousands of soil samples taken each year. The results of the sample test will indicate the necessary facts and recommendations concerning the soil. The test results will make available facts that will indicate whether the soil needs lime, nitrogen, phosphorus, and/or potassium.

The test will further determine the levels of calcium, magnesium, zinc, iron, manganese, and the percent of organic matter in the soil. Also, it will indicate if the soil has sufficient salt content to create a salinity hazard.

In addition to the above information obtained from the chemical test, the soil testing laboratories analyze the information supplied from the landowner and suggest fertilization and liming rates compatible with the desired production.

A. The Proper Time to Take Soil Samples

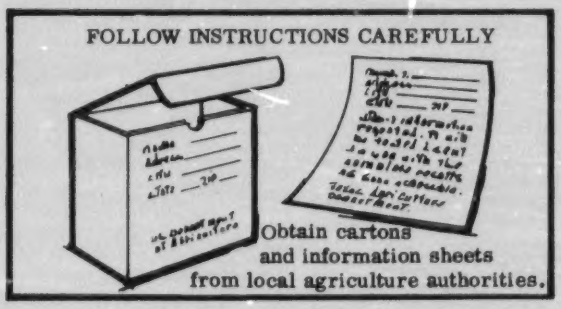
1. Samples may be taken any time during the

year.

2. The sample should be taken when the soil is dry enough to work readily.
3. The season of the year may assist in obtaining the results.
   a. It is recommended to take samples in the fall for spring planted crops.
   b. Sample in the summer for fall planted crops.
4. Take samples well in advance of the time the crop is to be planted. This practice will allow the testing laboratory ample time to return the results.
5. Soil samples should be made as a general rule:
   a. Once a year, for continuous row crops.
   b. Once per rotation of dairy farm rotation.

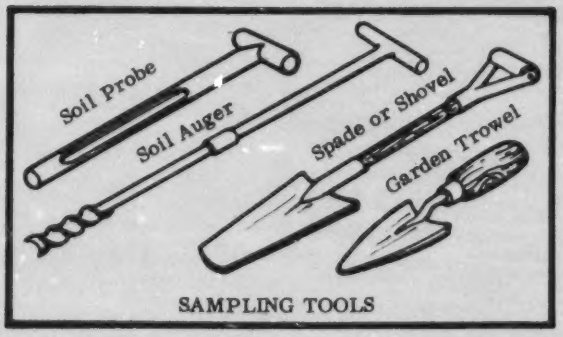
B. Procedure in Taking a Soil Sample

1. Get Complete Information--There are two important sayings:
   (1) Don't guess, soil test.
   (2) The soil test is only as good as the soil sample.



Obtain cartons and information sheets from local agriculture authorities.

When taking a soil sample, be sure you have the information needed for taking the sample. Information may be obtained from the vocational agriculture teacher or other local agricultural authorities in the county. The procedure in taking a soil sample may vary from state to state or even from county to county, due to local situations. The instructions on how to take a proper soil sample should be studied and followed very carefully.



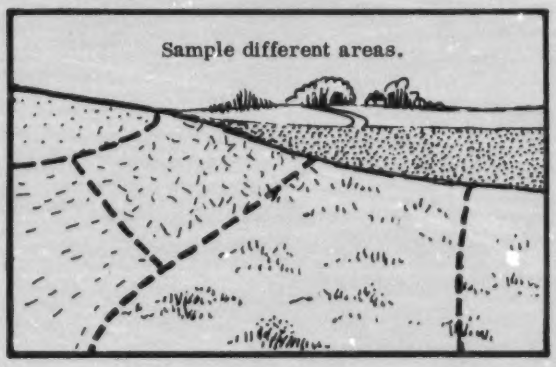
SAMPLING TOOLS

2. Select Proper Sampling Tools--A soil probe or auger is highly recommended for obtaining soil. If the soil probe or auger is not available, a garden trowel or spade may be used. A perfectly clean pail (bucket) is recommended for collecting the soil from each sample area. Feed dealers and agricultural authorities often have these tools to loan.

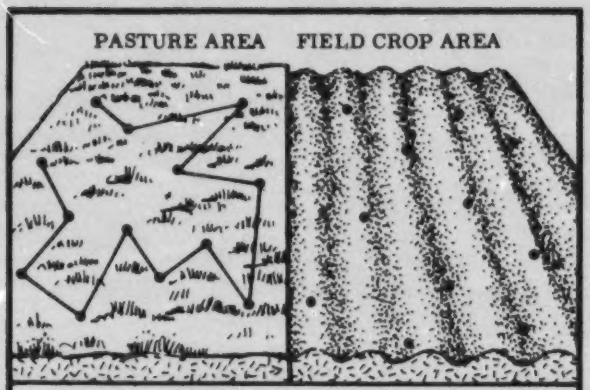
3. Watch for Unusual Areas--When taking a soil sample, avoid old fence lines, dead furrows, old manure and lime piles, terrace channels, snow fences, back furrows, windbreaks, wet spots, areas near trees, areas near the boundaries between slopes and bottomland, and areas near lime-rock roads.

Eroded Areas

4. The field to be sampled should be divided into different areas. It is usually recommended that each sample represent an area of not more than 8 to 12 acres. In areas where soil is uniform, it may be possible to use larger acreage per sample area. Be sure and sample separately all areas that have different crop growth, soil color, and past management. It would be wise to avoid all areas that are too small to be limed or fertilized separately.

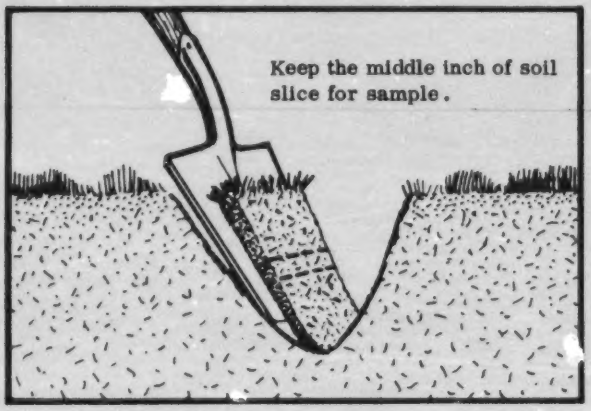

Sample different areas.

5. Take composite samples of soil from each area. The first thing that should be done after a sampling area is designated is to remove the surface litter from the spot where sample is to be taken. Soil should be taken from 10 to 15 spots in each area. As the soil is taken, it should be placed in a clean pail. The soil that is taken from a row crop field should be obtained between the rows and not from rows. If the samples are being taken on pasture areas take only about the top two to four inches of the topsoil.



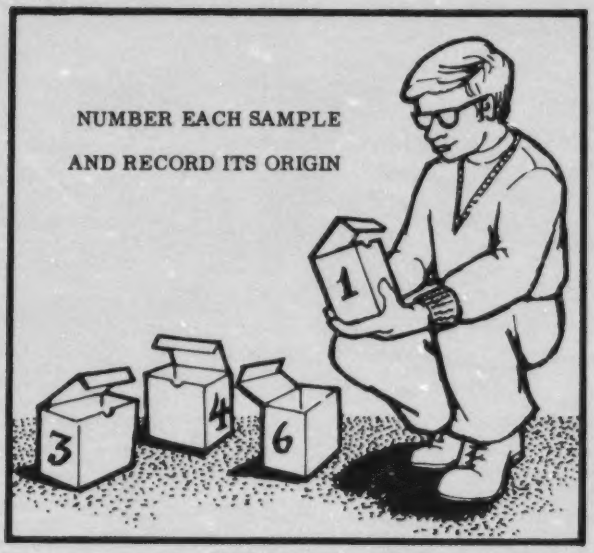
Collect a composite sample from 10 to 15 places.

6. When a sample is taken with a spade, a V-shaped hole should be dug to plow depth. Remove a ½-inch slice of soil from the face of the hole. Remove all except the middle inch of the soil slice. Place the one-inch slice in a clean pail.

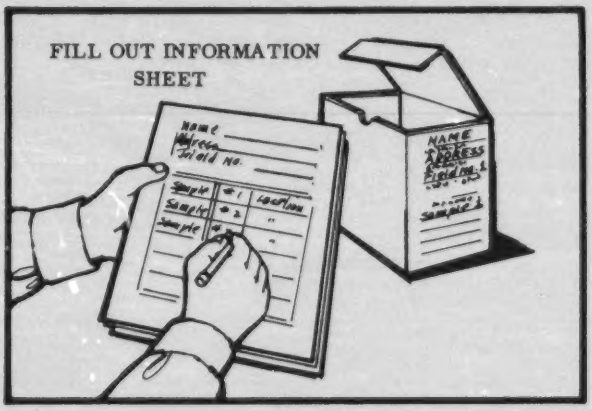


7. Mix Soil from Sample Spots—The soil taken from the sampling spots in each area should be mixed well in a clean pail. It is advisable to remove as much foreign matter as possible without changing the representative sample.

8. Identify Samples and Keep Records—Many times it is good to make a rough sketch of fields sampled and correspond them by number to an assigned number on the sample carton.



9. Fill out the Information Sheet—The extent of accuracy of the test results will depend not only upon the composite sample but also the information given about the sample. Soil sampling information should be filled out completely and accurately as possible on the information sheet and on the mailing carton. The finding and results of the person(s) conducting the soil tests can be no more accurate than the procedures followed and the information provided by the person taking the sample.



10. Follow Recommendations—The soil test will be of little value if it is not followed. The soil test results and recommendations should be studied carefully. The fertilizer dealer, vocational agricultural teacher, or other agricultural authority in the community can be of great assistance in helping you properly carry out your program.

C. Places to Send Soil Samples for Testing

There are several places in Texas to send soil samples. It is recommended that contact be made with local agricultural authorities to secure information concerning the nearest soil testing

laboratory in the area. Remember that all laboratories do not offer special tests that may be desired.

D. Soil Sample Information Sheets

There are several types of information sheets that may be used for the different soil tests. Included in this lesson are two of the commonly used information sheets:

(1) Soil sample information sheet for field crops, and
(2) Soil sample information sheet for lawns, gardens, and flower beds.

Other special information sheets are:

(3) Information sheet for salinity analysis of soil samples,
(4) Information sheet on soil samples for research purposes,
(5) Pecan leaf samples,
(6) Greenhouse tomato leaf samples,
(7) Rice soil samples, and
(8) Irrigation water analysis.

These information sheets may be obtained by writing to:

Texas A&M University
Texas Agricultural Extension Service
Soil Testing Laboratory
College Station, TX 77843

or contact your local agricultural authority.

TEXAS AGRICULTURAL EXTENSION SERVICE
THE TEXAS A&M UNIVERSITY SYSTEM
SOIL TESTING LABORATORY

SOIL SAMPLE INFORMATION SHEET FOR FIELD CROPS

To aid in interpreting the soil test and making recommendations, fill in the following information sheet as completely as possible and submit with your soil samples. Each soil sample should be marked with your name and sample number which should correspond with the information furnished on this sheet. See mailing instructions on opposite side under Step 4. (Do not send cash)

NAME _____ Date _____ CHECK ONE

STREET, ROUTE, BOX _____ County _____ Regular tests $2.00 per sample _____

POST OFFICE _____ Zip

Regular tests plus iron, zinc and manganese $5.00 per sample _____

EXTRA COPY TO: NAME _____

ADDRESS _____

A. SOIL CONDITIONS: (Use ditto and check marks wherever possible)

(Do not write in this column)	Your sample number	Location		To be irrigated		Limed during last 2 years		Remarks (Soil type or condition, problem)
		Upland	Bottom	yes	no	yes	no	

B. CROPS TO BE GROWN

C. CROPPING AND FERTILIZATION HISTORY

Your sample number	Next crop to be fertilized		Present or last crop 19?		Fertilizer Used	
	Crop or forage	Desired yield	Crop or forage	Yield	Rate	Analysis

D. GENERAL: (Please answer following questions if they apply to these samples.)

1. Will small grain be grazed? No _____ Yes _____ Which fields? _____
2. Will grass be used for hay only? No _____ Yes _____ Which fields? _____
3. Will grass be used for grazing only? No _____ Yes _____ Which fields? _____
4. If grazed, how many acres per animal unit is desired stocking rate? _____
5. Will a legume be grown in pasture? No _____ Yes _____ Which fields? _____
   If so, what? _____
6. What is the primary grass to be grown for pasture or hay on the fields sampled?
   Common Bermuda _____ Bahia Grass _____
   Coastal Bermuda _____ Love Grass _____
   Dallis Grass _____ Klein Grass _____
   Harding Grass _____ Native Range Grass _____
7. Is a grass to be newly established on the sampled area? No _____ Yes _____

Texas Agricultural Extension Service
The Texas A&M University System
Soil Testing Laboratory

SOIL SAMPLE INFORMATION SHEET FOR LAWNS, GARDENS AND FLOWER BEDS

This form is to be used for lawns, gardens and flower beds. Please fill out as completely as possible and mail with the soil samples. See opposite side for instructions on how to take samples and instructions for mailing. Be sure to enclose a check or money order for correct amount of fee.

Name_____

Address_____

County_____ Date_____

Post Office_____ Zip_____

Cost per sample (check):

Regular tests $2.00_____

Regular tests plus iron, zinc and manganese $5.00_____

Laboratory number (do not write in this space)	Your sample number	Condition of topsoil				Remarks (soil conditions)
		Loose	Heavy	Packed	Mellow	

Your sample number	Commercial fertilizer used		Organic material used (manure, compost, etc.)		Plants to be grown (lawn, vegetables, flowers, shrubs, trees)
	Kind	How much	Kind	How much	

Give size of area (dimensions or number of square feet):_____

How many years has garden (or lawn or flowers) been in this spot?_____

Do you have manures, compost, leaves or other organic material available each year? (Yes or No)_____ If so, how much?_____

What particular difficulties do you have with plant growth in this area?_____

10M—8-75, Reprint
Postage Paid

AGR 11-3

154

D-514C

cc: County ASCS

Soil Testing Laboratory
Texas Agricultural Extension Service—The Texas A&M University System

Soil Test Report

ASCS Farm No.

Name Address County

SOIL TEST RESULTS AND CLASSIFICATION

Lab. no.	Sender's sample no.	Soil reaction (pH)	Calcium Ca # / A*	level	Magnesium Mg # / A*	level	Predicted nitrogen level	Phosphorus P.O. # / A*	level	Potassium K.O # / A*	level	Salinity hazard	Zinc	Iron	Manganese	
9564	1	5.9	1700	H	215	M	L	22	L	310	M	None				

Levels
VL — Very Low
L — Low
M — Medium
H — High
VH — Very High
"+" means "more than"

*The values for pounds per acre is based on testing procedures used at Texas A&M soil testing laboratories and may differ from results obtained by other procedures. The level of very low, low, etc., is more important than pounds per acre, since these levels indicate the probability of response to added plant nutrients.

SUGGESTED FERTILIZATION AND LIMING RATES
(Please read back side of report and the enclosed leaflet.)

Sample no.	Crop	Limestone tons/A	Total plant nutrients per acre lb. N	lb. P.O	lb. K.O	REMARKS
1	Clover	2	0	80	40	Apply preplant or at planting time.
	Bahia or Bermuda		120	0	0	After clover. Topdress 60-0-0 in the early spring followed by 60 lbs of nitrogen per acre after each grazing.

If you have questions about this soil test report, see Mr. , your county Extension agent, who is located in

Recommended by Dr. Carl Gray Date samples received 3-29-78 Date completed 4-12-78

Postage Paid

YOUR SUGGESTED FERTILIZATION MEANS:

Total plant nutrients per acre		
lb. N	lb. P_2O_5	lb. K_2O

To convert these values to a specific grade of mixed fertilizer or a material, use this formula:

$$\text{lb. of fertilizer needed} = \frac{\text{lb./A of nutrient desired}}{\text{\% nutrient in fertilizer}} \times 100$$

Example 1:

lb. N	lb. P_2O_5	lb. K_2O
60	0	0

Fertilizer available, ammonium nitrate (34-0-0)

$$\text{lb. of ammonium nitrate needed/A} = \frac{60}{34} \times 100 = 176$$

Example 2:

lb. N	lb. P_2O_5	lb. K_2O
120	60	60

Fertilizer available, 12-12-12 and anhydrous ammonia (82-0-0)

$$\text{lb. 12-12-12 needed/A} = \frac{60\ (N,\ P_2O_5,\ K_2O)}{12} \times 100 = 500 \text{ lb.}$$

500 lb. 12-12-12 will supply 60-60-60

$$\text{lbs. anhydrous ammonia needed to supply remaining 60 lb. of N/A} = \frac{60}{82} \times 100 = 73 \text{ lb.}$$

LIME REQUIREMENT (TONS OF GROUND LIMESTONE PER ACRE)

The lime requirement is generally defined as the amount of liming material needed to establish and maintain the soil pH within the desired range for 3 to 5 years. To be most effective in neutralizing soil acidity and bringing the pH into the desirable range, liming materials should be applied at a time when mixing with the soil can be accomplished.

Liming permanent sods requires applying on the surface. Such applications are satisfactory for maintenance purposes.

For a liming material to be effective, it must be spread uniformly. Since liming practices have long-range benefits, they can be carried out at any period of the year when conditions are favorable.

156

ORGANIC MATTER

A high level of organic matter is desirable in soils that will be used for lawns, gardens and flower beds. To increase organic matter, incorporate organic materials at the rate of 250 to 300 pounds per 1000 square feet. High-nitrogen organic materials, such as peat, animal manures and well-decomposed compost, do best. Animal manures should undergo some decomposition prior to incorporation into the soil to destroy weed seed. Low-nitrogen organic materials, such as gin trash, cotton burrs, or rice hulls also are satisfactory. One pound of actual nitrogen should be incorporated with each 200 pounds of these low-nitrogen materials. After organic materials are incorporated, continue with the fertilization program which is recommended.

PHYSICAL CONDITION OF THE SOIL

Good physical condition of the soil is necessary for optimum growth of most plants. A soil with good aeration, good drainage and good water-holding capacity is desirable for most plants. If your soil is compacted and runs together easily, it would be beneficial to incorporate some type of organic material to improve the physical condition of the soil.

ACCUMULATION OF SOLUBLE SALTS

It is desirable to have a very low soluble salt level in soils. If your soil contains a low, medium or high level of soluble salts, these salts will be detrimental to plant growth. Seeds may fail to germinate or plants will fail to grow properly or be killed by the accumulation of salt in the soil. If salts are present, it is necessary to leach, or wash, the salts downward. If the area is small, mound up a 6 to 8 inch layer of soil around the area and flood the area with about 5 inches of water. You could also apply water slowly so that the water will move downward through the soil to a depth of 18 to 24 inches. The water will carry the salts downward as it moves through the soil. If soluble salts are medium or high, it may be necessary to repeat this leaching process. Soils that are heavy textured or high in clay content will be difficult to leach. Where certain types of salts are present, it might be desirable to apply gypsum to facilitate the movement of the salts downward. If gypsum is needed for this purpose, a recommendation will be given for this on the basis of the soil test. Salt normally accumulates from the application of water. To prevent further accumulation, water should be applied in sufficient quantities to wet the soil to a depth of 12 to 14 inches if possible. By applying this amount of water, the salt is continuously being leached downward and is not allowed to accumulate. Frequent light waterings will result in water moving back to the surface of the soil and evaporating, leaving salt to accumulate.

PLANT DISEASES OR SOIL INSECTS

If grasses, vegetables or flowers die, it is very seldom due to a lack of soil fertility but is probably due to some other factor, such as plant diseases, soil insects, or salt (as mentioned above). In case of plant diseases or soil insects, a soil test is of little value. If difficulties appear to be due to diseases or insects, see you county agricultural Agent for diagnosis and further information.

GLOSSARY OF TERMS

1. Debris - A term applied to the loose material arising from the disintegration of rocks and vegetative material; transportable by streams, ice, or floods.

2. Eluviation - The removal of soil material in solution (or in suspension) from a layer of soil. Usually, the loss of material in solution is described by the term leaching.

3. Podzolic - Soils formed in cool - temperate, humid climates under coniferous or mixed forest and characterized by a highly leached, whitish gray A_2 horizon.

4. Percolation - The downward movement of water through the soil in response to the pull of gravity.

5. Solum - The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons.

6. Hydromorphic - Developed in the presence of an excess of moisture which tends to suppress aerobic factors in soil building.

7. Stratum - A layer or sheetlike mass of sedimentary rock or earth of one kind lying between layers of other kinds.

8. Physiographic - Physical geography or a general description of nature or natural phenomena.

SELECTED STUDENT ACTIVITIES

1. The major soil horizons which make up a soil profile may be identified as
   "A" horizon or _____,
   "B" horizon or _____,
   "C" horizon or _____, and
   "D" horizon or _____,

2. The combined "A" and "B" horizons, the major parts of a soil profile, are called the _____ or true soil.

3. Complete the soil classification scheme below stating specific characteristics about soils in your geographic region or county.
   Soil location: _____
   ORDER _____
   SUBORDER _____
   GREAT GROUP _____
   SUBGROUP _____
   FAMILY _____
   SERIES _____
   TEXTURAL CLASS _____
   TYPE _____
   PHASE _____

4. In order to become better acquainted with local soils invite a local Soil Conservation Service (SCS) technician to present a program on soil classification. (Indicate tentative plans here.)

5. Review a Soil and Water Conservation Plan. (This can likely be obtained from the S.C.S. technician mentioned in activity 4 above.)

6. List the steps suggested for taking a soil sample.
   (1)
   (2)
   (3)
   (4)
   (5)
   (6)
   (7)
   (8)
   (9)

7. Secure soil sampling information sheets from your vocational agriculture teacher or write to the Soil Testing Laboratory at Texas A&M University; then collect a soil sample from an appropriate location and send it to a soil testing laboratory for analysis.

8. Assume that a soil test report for the home lawn suggests a nutrient need of 60 lbs. N, 60 lbs. P_2O_5, and 60 lbs. K_2O. If a 12-12-12 grade fertilizer is available how many pounds per acre is needed to meet this requirement? (Write out the formula used to calculate the amount of fertilizer needed.)

9. Which of the following is a balanced fertilizer? (16-6-12), (10-20-10), or (13-13-13). _____

10. Which of the following is not a complete fertilizer? (12-12-12), (21-0-0), or (10-10-10). _____

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Vocational Instructional Services
Texas A&M University
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CONSERVING SOILS

I. KINDS OF EROSION

A. What is Erosion?

Erosion* is the wearing away of the soil by forces of water and wind. The impact of the falling raindrop on bare soil is the major factor in starting the process of erosion. High wind blowing across unprotected soil causes severe losses of soil moisture and displaces soil particles. Soil erosion is present at higher elevations all over the United States, regardless of the amount of rainfall received.

B. How Does Erosion Take Place?

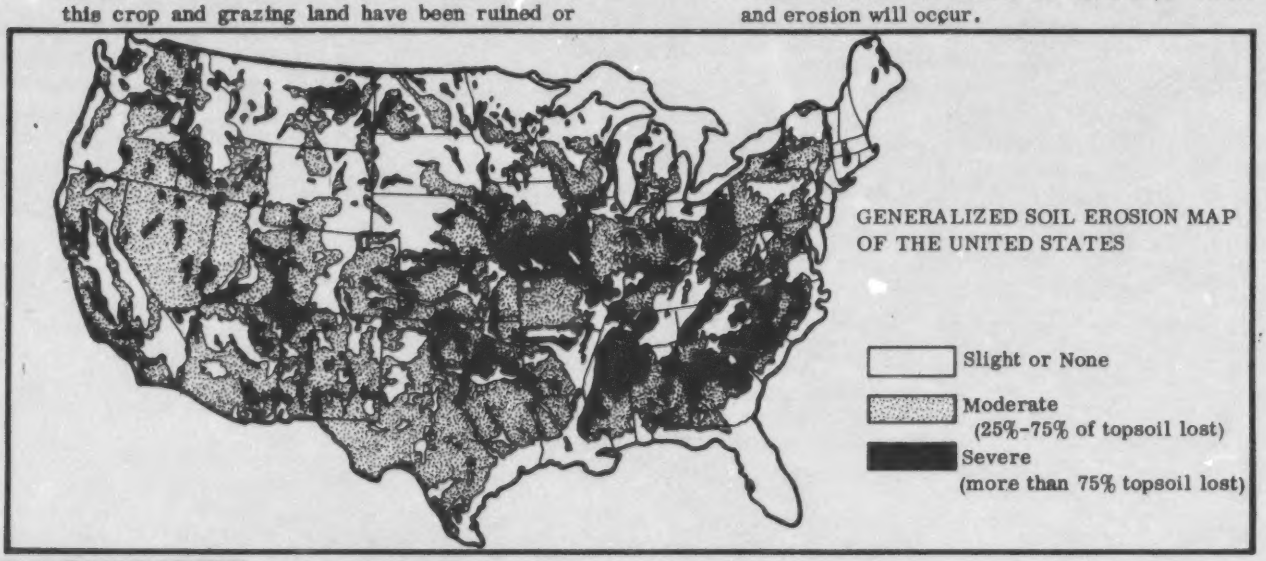
Nature has provided protection for soil in the form of vegetative cover. Vegetation protects the soil by breaking the force of raindrops and holding the soil together by root system. Man, however, has upset the balance by removing vegetation and leaving the soil defenseless against the climatic forces of water and wind.

C. Erosion in the United States

The United States has approximately 2,226 million acres of land of which 1,089 million acres were considered as farmland in 1973. Cropland and grassland pasture make up about 934 million acres of this total land area. The Soil Conservation Service has estimated that 282 million acres of this crop and grazing land have been ruined or heavily damaged by some form of erosion. They also estimate soil losses by erosion in our country at five and one-half billion tons annually. Losses from farm lands each year are estimated at three billion tons. This would be enough soil to fill a freight train that would reach around the earth 18 times. The equivalent of fifty 160-acre farms in topsoil is lost each day. Annual losses in dollars are estimated at nearly four billion, while the indirect effects of soil erosion cost additional hundreds of millions of dollars. Erosion contributes not only to soil losses from flooding but also to damaging highways, railroads, and homes, and to causing loss of human lives.

This soil erosion map of the United States shows the relative degree of soil erosion for generalized locations in the various states. In Texas, for example, a majority of the state falls within the moderate erosion category. This would give some indication of the varying topography and rainfall across the State.

Level areas have little or no erosion while areas that are hilly suffer most from erosion. In areas that receive 30 inches or more of rainfall annually, most erosion is caused by water. When the rainfall is less than 20 inches, wind becomes the major eroding force. Both wind and water will cause erosion where the rainfall is between 20 and 30 inches. When rainfall exceeds the rate at which the soil can absorb the moisture, runoff and erosion will occur.



*Underlined terms are defined in the "Glossary of Terms."

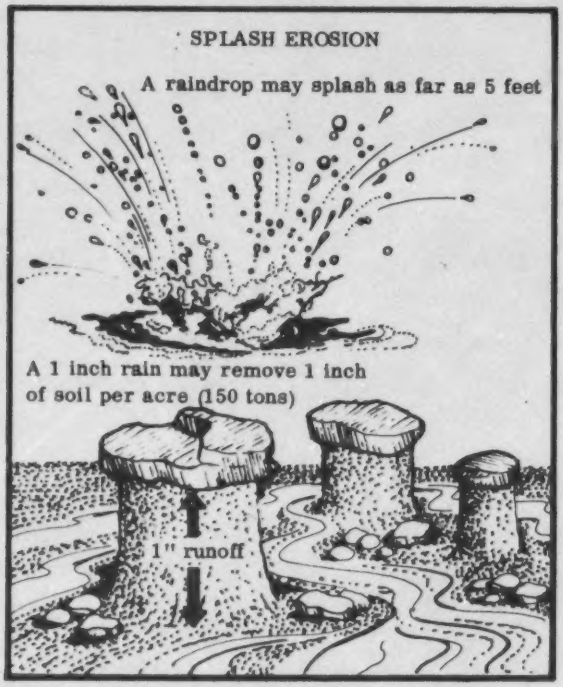
D. Kinds of Erosion

As previously mentioned, soil erosion is caused by two primary sources, water and wind. Both of these kinds of erosion occur from either natural causes or man-made causes. Natural erosion or that form of erosion occurring without interference by man is called "geological erosion." There has always been geological erosion, and there always will be. It is the other form of erosion, "man-made," that results from man's endless efforts to subdue the land for his own personal gain without due regard for his posterity. Since man can be credited with the causes of much of the erosion that has reduced the productive capacity of the land, it is man that must bring about the changes for correcting these deficiencies.

1. Water Erosion

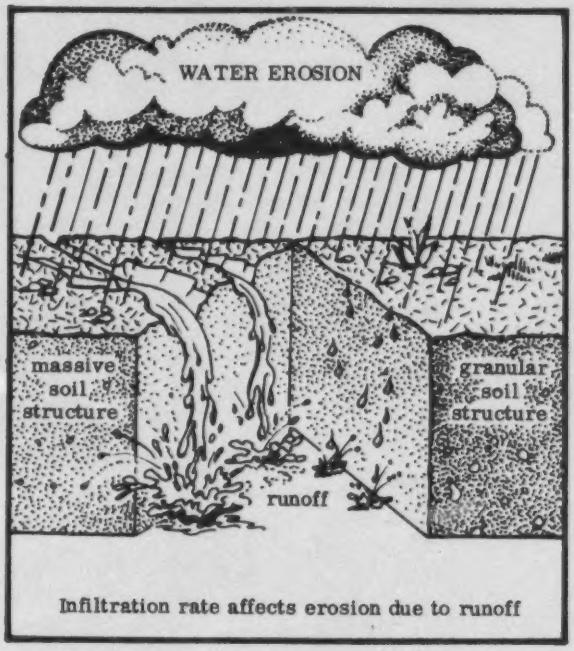
Soil is eroded by water in two stages, detachment and transportation. Falling raindrops on bare soil produce the first effect of soil detachment, while another force, running water, is responsible for the second stage, transportation.

a. Soil detachment by raindrops



The effect of falling raindrops is known as "splash erosion." A single, beating, one-inch rain may splash as much as one inch of soil depth by raindrop erosion. The dead weight of one inch of surface water on an acre is more than 100 tons. For an idea of the force involved in splash erosion, the weight of an acre of soil one inch deep is approximately 150 tons. Thus, 150 tons of soil an acre may be removed through splash erosion. Movement of soil by splash erosion is the primary cause of sheet erosion.

Another effect of raindrop erosion on bare soil may be to seal the soil from infiltration during the first few minutes of a hard rain. Tests have revealed that water runoff on bare soil starts within one to four minutes of the beginning of the rainfall, and that from 95 to 98 percent of the rainfall is lost as runoff.



Infiltration refers to the absorption of water into the soil.

When the rate of rainfall or intensity is greater than the ability of soil to absorb water in the form of infiltration, runoff will occur. There is an important relationship between runoff, rainfall intensity, and infiltration rate. One way to state this example is the formula:

Runoff rate = Rainfall intensity - Infiltration rate

A high infiltration rate will occur only when the surface soil is in such physical condition as to provide channels through which water can move as rapidly as it falls on the surface. Water which cannot move into the soil is lost from the surface as runoff, often carrying soil with it.

b. Runoff water is also a factor in soil erosion. As runoff water moves over the surface of the soil, the tendency is to flow along the paths of least resistance; therefore, some of it concentrates in low places to form channels. Continued flow

160

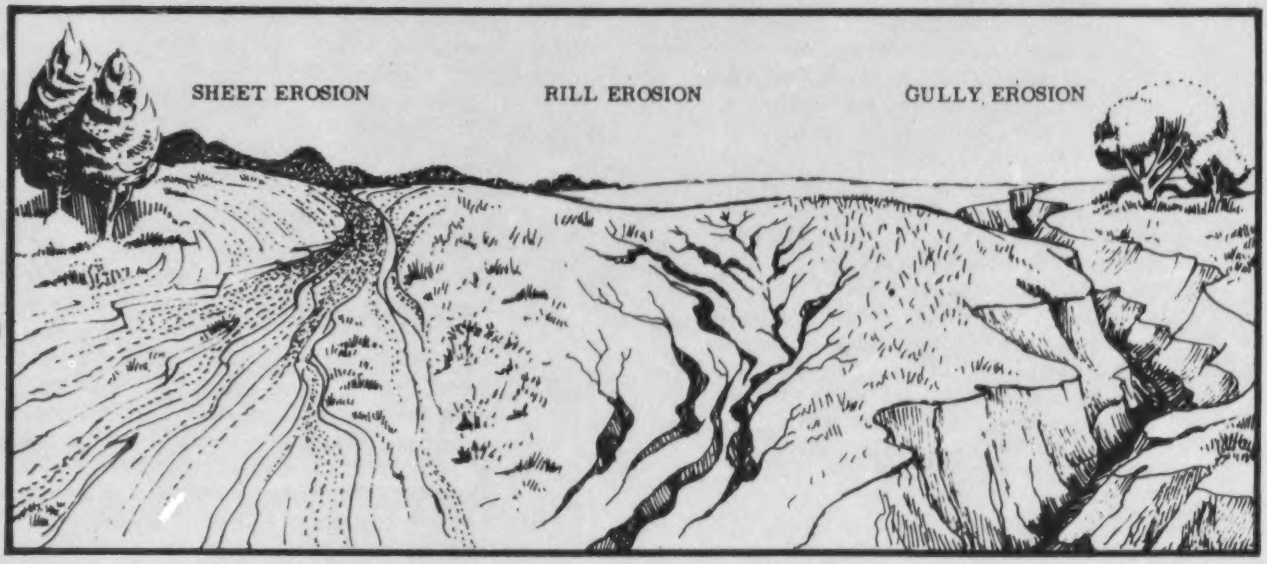
in these channels develops minor rills, and eventually large gullies may be formed by the increasing volumes of runoff water.

The common types of soil erosion caused by running water are sheet erosion, rill erosion, and gully erosion.

(1) "Sheet erosion" is the removal of soil in a uniform layer from an entire surface area. This type of erosion occurs continuously over periods of time, and the landowner may hardly be aware of its existence. It will also occur whenever surface runoff water flows across unprotected land. A shallow surface topsoil over a dense impervious subsoil is especially vulnerable to this type of erosion.

(2) "Rill erosion" is a mild form of gully erosion. Small channels are made by running water in small streams over the surface of the soil. Rill erosion will appear as small fingers in a field or on an unprotected rangeland area. Damage may appear to be minor, but if left unchecked, rill erosion can do a vast amount of damage.

(3) "Gully erosion" is the most noticeable form of erosion. It is an advanced stage of rill erosion and occurs when rills flow together into larger streams. Gullies will often begin in slight depressions in fields. Tractor ruts, field roads, and livestock trails are logical places to look for gully erosion to begin.



c. Another type of water erosion that is sometimes overlooked is waterfall erosion. This type results from water flowing over dams, over terraces, at the head or along the sides of gullies, and other places. The great force that is generated by the falling water will cause severe damage if not controlled.

d. Water Erosion Controls

Soil conservation measures for the prevention of soil losses and for the control of water erosion include both cropping and mechanical measures.

(1) Cropping practices such as subsoiling or chiseling, contour furrowing, contour listing, stubble mulching, and strip cropping are an attempt to give as much protection to the ground surface as possible. These practices also serve to increase the absorption of rainfall.

(2) Mechanical measures are designed to supplement the cropping program as well as control the movement of large quantities of rainfall on steeper slopes. Some mechanical practices are terracing, diversions, grassed waterways, land drainage, land preparation (shaping, smoothing, and leveling), and construction of ponds and dams.

2. Wind Erosion

Wind erosion occurs mainly in the Great Plains section of the United States where rainfall ranges from 16 to 20 inches. The storms encountered by the settlers were "sand storms," i.e., the wind carried large par-

ticles for short distances. In 1934, however, man encountered a new type of storm, the dust storm. The storm struck following a drought in the Great Plains and lifted an estimated 300 million tons of topsoil from the earth. The soil piled against fences and buildings; it covered crops and roads and drifted across the continent to the Atlantic coast. This storm was followed by many more which gave the name of "dust bowl" to the Great Plains region of Kansas, Colorado, New Mexico, Oklahoma, and Texas.

a. Damages Caused by Wind Erosion

In observing the evidence of wind erosion in very arid desert regions or along sandy sea shores, one would notice sand drifts or sand dunes resulting from geological wind erosion. Moving into the more productive areas, the type of wind erosion observed would be the result of poor land use. Sandy soils which have been overplowed, overgrazed, or overcut soon dig out without a protective cover and become subject to losses by wind erosion.

In areas subject to wind erosion where the original grass sod has been destroyed, the soil surface becomes dry, and these sandy soils are frequently shifted about by the wind. As the wind increases in velocity, deeper layers of soil are dried out and water, which helped to bind the soil particles together, is lost rapidly by evaporation. The result is a greater loss of the more fertile fine sand and silt particles that are carried away as "clouds of dust."

b. Wind Erosion Control Practices

Control measures, which to a large extent have been effective, have been taken to reduce the hazards of wind erosion. These measures include strip cropping, prevention of burning, protection from overgrazing, moisture conservation, planting cover crops, use of emergency tillage operations, planting tree windbreaks, and planting a shelter belt of trees.

II. FACTORS INFLUENCING SOIL EROSION

On any given piece of land there are a number of factors that affect erosion. Some of these factors are nature of the soil, climate, vegetative cover, slope and horizontal length, and management of the soil. A discussion of the factors follows.

A. The Nature of the Soil

1. Texture—Soils with high clay content do not erode as easily as soils that are sandy or silty. The clay particles tend to stick together and, therefore, have a stronger bond than do other types of soil. Silty soil is loose and tends to erode easily. Sandy and loamy soils will absorb water and reduce runoff but will wash in heavy rains.
2. Structure—Good structure will hold the soil together giving the water a chance to sink in. Before particles are washed away they must be detached. Crumb and granular structure are the most desirable since they allow moisture to move through the clusters as aggregates of soil particles, thus reducing runoff and increasing the amount of moisture to the plants.
3. Depth of the Soil—Deep soils will take up much rain water if they are permeable. This will help to reduce runoff since the more that is absorbed the less is available for runoff. Soils with hardpan layers near the surface will not absorb much water and are more susceptible to erosion.
4. The Organic Matter Content—Soils with high organic matter content have increased absorptive capacity. They also increase plant growth which provides protection from the elements.

B. Climate

1. Climate is the combined effect of wind, temperature, and rainfall. Rainfall is considered the primary eroding force in Texas. For over 7,000 years it was thought that only running water caused erosion. In the last few years, however, raindrop splash has been recognized as a major factor in erosion. Raindrop splash can be defined as the force of impact of raindrops upon the soil. The tremendous force of raindrop splash can be observed by noticing how dirt is splashed upon a house during a rain. Some of the ways that raindrop splash affects the soil are:
   a. Gradually moves the finer materials from the soil and leaves less fertile, coarser sands, and gravels.
   b. Detaches soil and breaks down soil structure. Such finer particles are more easily transported, and erosion is thus accelerated. This means that raindrop splash is causing a gradual downhill movement on a hillside.
   c. Tends to seal the surface by causing puddling of the soil. Infiltration is reduced and produces higher surface runoff.
2. The higher runoff, in turn, is able to transport more material. Thus, a hard-beating rain brings about a vicious cycle, multiplying erosion in many ways. Water erosion is a product of both splash erosion and erosion caused by water flowing over the surface.

C. Vegetative Cover

1. Soil that is covered is protected from the forces of raindrop splash and running water. The good farmer recognizes the importance of vegetative cover in controlling erosion. The more cover the land has, the less erosion will take place. Vegetation will hold the soil particles together, cushion the impact of raindrops, and increase infiltration, all of which will decrease erosion.

2. The following table from a Missouri experiment station bulletin shows the effect of cover or cropping systems on the rates of erosion and runoff:

Cropping System	Average Annual Rate of Soil Loss in Tons Per Acre	% of Total Rainfall Running Off the Land
Bare, cultivated, no crop	41.0	30
Continuous corn	19.7	29
Continuous wheat	10.1	23
Rotation: corn, wheat, clover	2.7	14
Continuous bluegrass	0.3	12

D. Slope and Horizontal Length

1. The steepness and horizontal length of land will have a great effect on erosion. As water moves down a slope, it increases in velocity and carrying capacity. For example, doubling the percent slope will increase soil loss 2.5 times. Doubling the length of slope will increase soil loss 1.4 times.
2. The slope should always be considered in determining the use of land. Cultivation of steep land should always be avoided.
3. Slopes can be classified as follows:
   a. Nearly level — Less than 1 foot fall in each 100 feet
   b. Gentle sloping — 1 to 3 feet fall in each 100 feet
   c. Moderately sloping — 3 to 5 feet fall in each 100 feet
   d. Strongly sloping — 5 to 8 feet fall in each 100 feet
   e. Steep — 8 to 12 feet fall in each 100 feet
   f. Very steep — Above 12 feet fall in each 100 feet

E. Management of the Soil

The way the soil has been managed will determine, to a large degree, the amount of erosion. Bad management practices will destroy good land. The good farmer recognizes erosion as a problem and works to overcome it. In the following topics, we will study some of the practices that will help to control erosion.

III. EROSION CONTROL MEASURES

What Are Some Management Practices that Will Control Erosion?

There are many methods that are used to control erosion. The best methods for any farm can be determined only through study of the soils found on the farm and the particular situation. Since soils differ from field to field, each field is a separate problem in erosion control. As soon as the soils are identified on a farm, the following management practices should be considered: efficient use of the land, water disposal system, cover crop, fertilizer and lime, control of gullies, and erosion control plan. These practices will be discussed in the following paragraphs.

A. Efficient Use of the Land

Efficient use of the land should be the primary consideration of any good farmer. By efficient use is meant the use of land in such a way that maximum income and satisfaction is realized with minimum damage to the land. For example, crops planted on steep land may result in more loss due to damage to the land than is realized from the added income. The farmer should try to use the land in such a way that he will realize income while at the same time protect the land.

Some of the factors to be considered in making the decision of which crop to plant are:

1. Nature of the Soil
   a. Steepness of the land
   b. Will erosion be a problem to control?
   c. Is the crop suited to the soil conditions?
2. What is the potential income that can be provided by the crop?
3. What are the personal preferences of the landowner under existing soil conditions?
4. What effect will the production of this crop have on the land?
   a. Removal of soil nutrients
   b. Continuous use of this crop on soil conditions
5. How will the crop fit into the present crop rotation system?

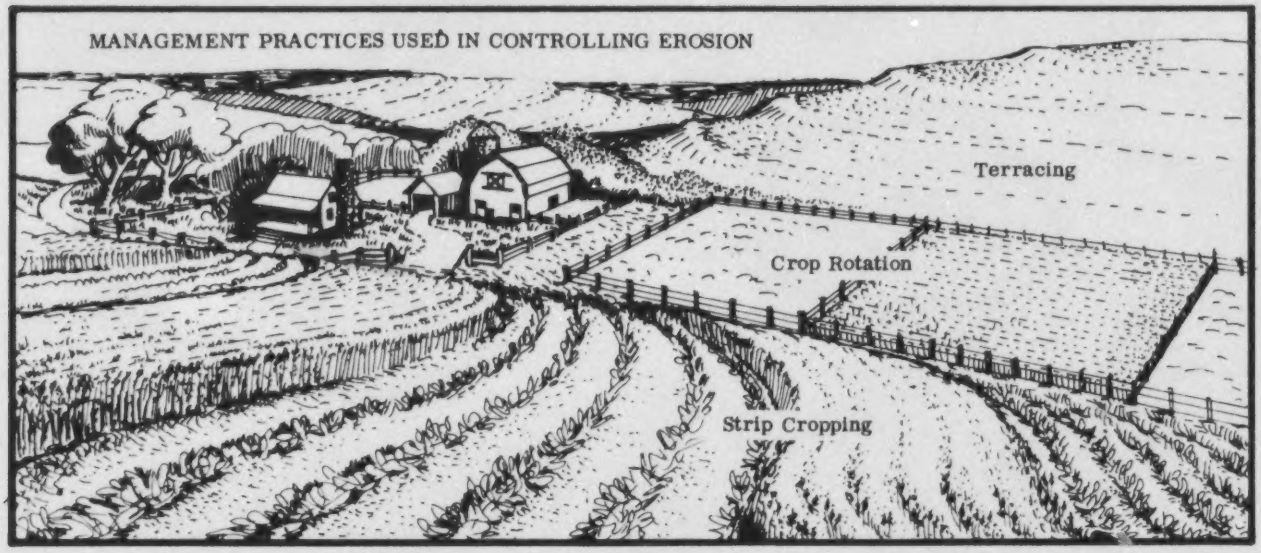
B. Water Disposal System

In high rainfall areas, more rain is received than the soil can take up. Since the excess water will run off the land, steps should be taken to insure that water runs off with a minimum of soil washing. Some of the steps in controlling water runoff are:

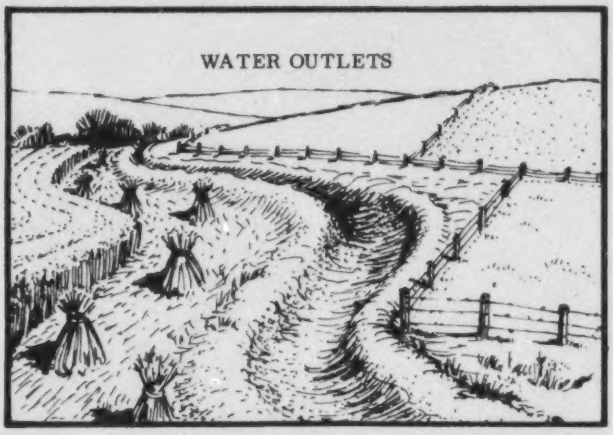
1. Terracing—A terrace is the structure designed to slow down running water and control erosion on sloping land. When planning terraces one should consider their width, height, length, outlets, and direction. Terraces will usually empty into a grass waterway or concrete flume to prevent gullying at the point of the outlet. They are built so that

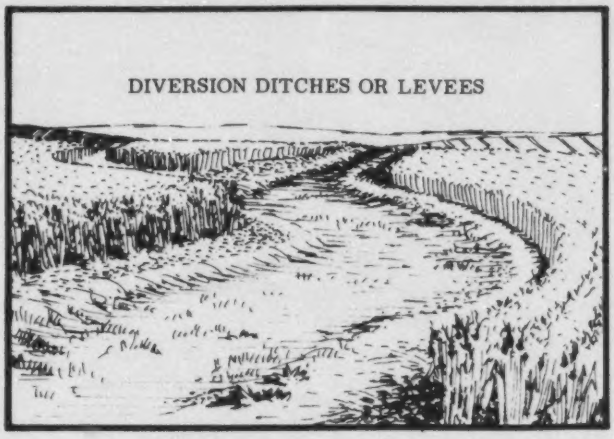
there will be only a slight fall between them to slow down running water.

2. Strip Cropping—Strip cropping is the practice of planting crops in narrow strips, in which close growing crops are grown next to cultivated crops. The principle is for the meadow crop to slow down the water moving down the slope. These strips are plowed on the contour. The width of the strip depends on the percent and length of the slope and the soil type.
3. Crop Rotation—The rotation of a field from a row crop to a sod-type crop retards erosion by increasing the amount of organic matter in the soil and by providing cover for the surface on years when the close growing crop is grown.

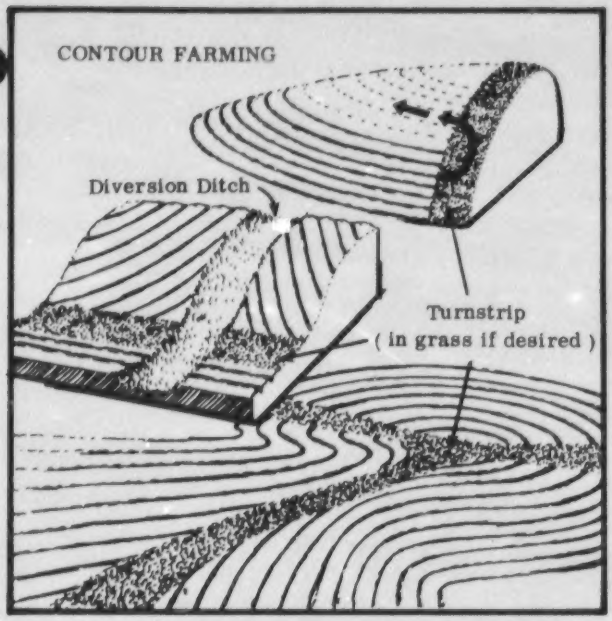


4. Water Outlets—Water outlet refers to the ditch which carries the excess water off the farm. In recent years, grass waterways have come into importance as a water outlet method. Other outlets include metal culverts and concrete ditches. Attention should be given to the major water outlets to insure that no gullies form.
5. Diversion Ditches or Levees—Diversion ditches are around the upper end of a field but care must be taken to assure that they do not cause damage by cutting off the water course itself or forming gullies where the water is released.
6. Contour Plowing—Contour plowing is the most fundamental step toward erosion control on cultivated land. It reduces runoff by temporarily holding back the water and allowing more time for penetration. In many cases, where the slope is gentle, proper row direction may be the only erosion control method needed.
   a. Step 1 — The first operation in contour plowing is to establish a contour guide line that runs across the field or around the slope at a constant level. Then the remainder of the field can be plowed using this as a guide.
   b. Step 2 — Continue plowing but leave a turn strip at the lower part of the field. Plow around the contour guideline, lifting the plow from the ground when crossing the waterway.





c. Step 3 — Continue from step 2 by plowing out the area, leaving the turnstrips in grass if desired.



C. Cover Crops

Land which is not suitable for cultivated crops due to soils, slopes, or erosion may be critical areas which should be covered with vegetation. The kind of vegetation will depend on soils and the need which the farmer needs to make of such plants. Deeprooted legumes such as lespedeza and kudzu provide good cover and grazing. Trees can sometimes be used as a cover crop. Cover crops will not only protect poor areas from erosion, but also provide a source of additional income.

D. Use of Fertilizer and Lime

While fertilizer and lime do not have a direct effect on erosion, they do have a great indirect effect. Soils that are fertile will cover faster and more uniformly than unfertile soils. Cover crops need fertilizer to cover properly and protect against erosion. This is also true of cultivated crops. The quicker their root systems expand to bond the soil together, the less likely the chances for erosion. The farmer should certainly consider the fertility requirements of his soil when planning an erosion control system.

E. Control of Gullies

Since gullies are formed by water being concentrated into a central area, the first step in controlling them is to divert the water from that area. This can be done by using a terrace or diversion ditch.

The next step is to provide protective vegetation for the gully. Brush dams are a good method to hold the soil and water until it is possible to start plants. Kudzu is a good plant to stop gullies where the soil is suitable. Trees can be used to provide an effective control for deep gullies, but time should be provided to get started. Grasses provide good cover to stop the washout in a gully. Native grasses are best suited to gully plantings in most areas. Once cover is established, the gully can be used for grazing or other purposes.

When a gully is planted, it may be necessary to do some bank sloping, particularly if the area is steep. Usually a satisfactory growth can be established without extensive sloping. In some areas, monetary assistance on a fund matching basis can be obtained through the local A.S.C.S. office for gully sloping programs carried out by the landowner.

F. Erosion Control Plan

Every farm should have some sort of soil erosion control plan. Assistance can be obtained from the local Soil Conservation Service (SCS) office in making a conservation plan to protect the land against erosion. A system of disposing of excess water is necessary on all farms and ranches on which excessive runoff occurs. The natural processes of erosion have created natural drainage patterns. The runoff from and within fields is collected in these natural drainageways and carried to main-stream channels. A conservation plan provides for using natural waterways to carry runoff and for shaping land where necessary to make water courses large enough to carry runoff at nonerosive velocities. This plan also provides for the maintenance of channels in grass.

When planning for erosion control, there are many factors that one must consider. The following list will provide a guide to some of the considerations:

1. The Effect of Erosion on the Farm
   a. Effect on the value
   b. Effect on the production now and in the future
2. The Effect of Erosion on the Community
   a. What is the farm's value to the community?
   b. How other farms are faced with the same problem
3. What type of erosion control practice will you use?
   a. What kind of land do you have?
   b. What control practices are best suited for your land?
4. Cost of the Erosion Control Practices
   a. Can you afford them?
   b. Can you afford not to use them?
5. What are some of the benefits you will realize from erosion control?
6. How will the erosion control plan be implemented on the farm or ranch?

GLOSSARY OF TERMS

1. Erosion - Detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

2. Infiltration - The downward entry of water into a soil. Infiltration rate denotes how rapidly a soil will absorb water.

3. Impervious - A soil that will not absorb water or through which plant roots cannot penetrate.

SELECTED STUDENT ACTIVITIES

1. After reading each of the statements below, indicate whether you agree or disagree with the statement by underlining the response of your choice. If you disagree, then state your reason for disagreeing.

   a. Soil erosion is present at higher elevations all over the United States, regardless of the amount of rainfall received. (agree, disagree)

   b. When the rainfall is less than 20 inches, wind becomes the major eroding factor. (agree, disagree)

   c. There has always been "geological erosion", and there always will be. (agree, disagree)

   d. A one-inch rain can remove up to one inch of soil per acre. (agree, disagree)

   e. Water runoff on bare soil starts within one to four minutes of the beginning of rainfall, and from 95 to 98 percent of the rainfall is lost as runoff. (agree, disagree)

   f. A high infiltration rate will occur only when the surface soil is in such physical condition that water can move through it as rapidly as it falls on the surface. (agree, disagree)

   g. "Sheet erosion" is the most noticeable form of erosion. (agree, disagree)

   h. A combination of cropping practices and mechanical measures will likely provide the best means for controlling water erosion. (agree, disagree)

   i. Sandy soils which have been overplowed or overgrazed without a protective cover are more subject to losses by wind erosion. (agree, disagree)

   j. Crop rotation is the practice of planting crops in narrow strips in which close growing crops are grown next to cultivated crops. (agree, disagree)

   k. Soils that have fertilizer and lime applied to cover crops will generally cover faster and more uniformly. (agree, disagree)

   l. Native grasses are best suited to gully plantings in most areas. (agree, disagree)

   m. A system of disposing of excess water is needed on farms and ranches on which excessive runoff occurs. (agree, disagree)

   n. Land which is not suited for cultivated crops due to soils, slopes, or erosion may be critical areas which should be covered with vegetation. (agree, disagree)

   o. Assistance in making a conservation plan can be obtained free of charge from local Soil Conservation Service (SCS) personnel. (agree, disagree)

2. Looking at the generalized soil erosion map of the United States, what category of erosion more typically represents the degree of erosion in the area in which you live?

3. Which type of erosion (water or wind) causes the greatest losses each year in the general area in which you live?

4. List the common types of soil erosion caused by running water.
   a.
   b.
   c.
   Now, indicate which of these types of erosion causes the greatest losses of soil in the general area in which you live. _____ erosion

5. List some cropping and mechanical practices which are being carried out in your local area to help prevent soil losses from erosion (either water or wind).

Cropping Practices	Mechanical Practices
a.	a.
b.	b.
c.	c.
d.	d.

6. What are some of the kinds of plants that are used as cover crops in your local area for protection against soil erosion?
   a. c.
   b. d.

7. Record the following pertinent information about your local SCS program.
   a. Name of local Soil Conservation District, _____
   b. SCS office location, _____
   c. SCS office supervisor, _____
   d. Has your local Soil Conservation District completed a conservation "Program and Plan" for the district?

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College Station, Texas 77843

CONTROLLING SOIL WATER LOSSES

I. WHAT IS SOIL WATER ?

Soil water can be thought of as the moisture in the soil. Soil water plays an extremely important part in the growth of plants. Since all soils have some degree of moisture, the amount that is available for plant growth becomes of primary importance. For the farmer, the conserving of soil water is an attempt to prevent drought. We know that plants take moisture from the soil with their roots and transport it to the leaves which pass it on to the atmosphere by transpiration. Drought can be said to exist any time that the demand for water from the leaves is greater than the supply from the roots. Too little moisture will prevent plants from utilizing their full potential. Some of the ways soil water serves plants are discussed below.

A. Water Is Essential for Plant Growth

Water is a necessary constituent of plant protoplasm, making up 85 to 90 percent of the fresh weight of actively growing plants. It is essential for maintaining the proper form and position of leaves and new plant growth. Plants require a supply of water from germination to maturity. When the water supply is cut off, green plants will wilt and die within a short time. The point at which they wilt is known as the wilting point.* Even trees contain more than 50 percent water.

B. Water Is Necessary for Soil Formation

Water is a necessary ingredient in soil formation. It aids in the weathering of rocks and breaking down of minerals that make up a large portion of the soil. The formation of a soil profile is also largely dependent upon water.

C. Water Makes Nutrients Available

In order for plants to function properly, they must have a food source. Water dissolves nutrients and makes them available to the plant in solution form. The roots are better able to take in the nutrients in solution. Fertilizer and lime are dependent upon water to dissolve them so that they will be available to the plant; without moisture, they have little effect.

Although plants absorb some water from rain and dew, most of the water used by plants comes from water held by the soil.

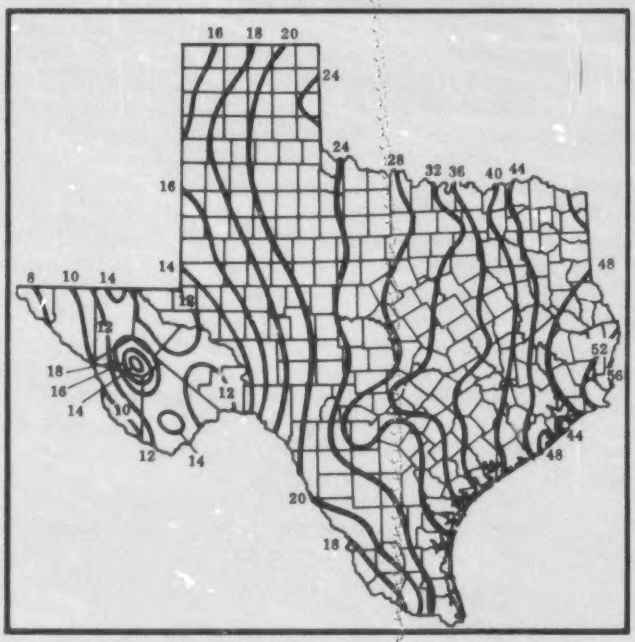
D. The Physical Condition of the Soil Is Influenced by Water

A cultivated loam soil in good physical condition for plant growth is comprised of approximately half solids (sand, silt, clay, and organic matter) and half pore spaces. The pore spaces are occupied by half air and half water; and only half of the soil water is available to plants. The other half of the soil water is held in thin films and in gaseous form and plants cannot absorb it.

The farmer is often interested in soil water as it affects the soil in preparing a seedbed. Heavy soils, such as clay, are sticky and tough when the moisture is high. When it is low, they are hard and do not work well. Farmers often use the process of wetting and drying on heavy soils so that they may be worked.

II. HOW DO SOILS GET MOISTURE ?

Rainfall is the primary source of soil moisture.



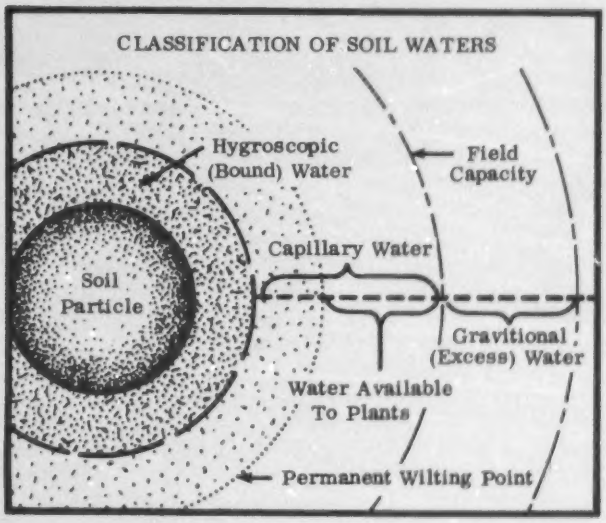
This illustration shows the average rainfall for the different areas in Texas. There is a gradual decrease from east to west. Although average rainfall figures are deceptive, they do give the farmer a basis for

*Underlined terms are defined in the "Glossary of Terms."

planning. For example, in the western regions, the farmer must plan for irrigation while in the eastern portion of the state there is ample moisture without irrigation.

III. KINDS OF SOIL WATER

There are three kinds of soil water that we will be concerned with. These are capillary water, hygroscopic water, and gravitational water.



A. Capillary water - Capillary water is the water that adheres to the soil particles. This type of water will move in the soil by "capillary attraction," from one soil particle to another. The finer the soil, the more surface is exposed for capillary water to adhere to. The capillary water, therefore, will be higher in fine soils, such as clay, than in coarse soils, such as sand. When the amount of capillary water is high, it is removed from the soil easily by the plants, but as more is removed, it becomes harder for the plant to get the moisture it needs. When the amount of moisture is decreased below the level needed by the plant, wilting occurs. Capillary is by far the most important soil water for plant growth. Capillary water will evaporate during periods of drought.

B. Hygroscopic water is held tightly by the soil particle. It is not available for plant growth. Even in very dry soils, some hygroscopic water is present since complete removal requires baking the soil in an oven for long periods of time.

C. Gravitational water is the free or excess water in the soil. It can be moved by the force of gravity. Fields with poor natural drainage may contain gravitational water. This type of water is available to the plants, but causes unfavorable conditions to occur. When the soil is waterlogged, plant roots do not function normally because they cannot get enough air to do so. Rice is one of the few crops that will grow when gravitational water is present in large quantities. Drainage is sometimes necessary to remove gravitational water.

IV. MEASURING SOIL MOISTURE

Regular inspection of soil moisture conditions can provide valuable information about the amount of soil moisture in the soil. It can be used as a basis for determining when to irrigate or as a basis for other management decisions. For most crops, irrigation should begin when the soil moisture drops below 50 percent of the available soil moisture.

A. A practical method of estimating available soil moisture is to squeeze a small amount of soil to farm a ball. Table 1 gives a description of the feel and appearance of different textured soils containing various moisture percentages.

Estimating soil moisture by feel and appearance is not a precise measuring method. However, this method is effective if results are observed carefully. For example, suppose you have a sandy clay loam soil which you estimate contains an average of 50 percent available moisture in the root zone depth of three feet. If you estimate the soil should hold 2.0 inches of available moisture per foot of soil, or a total of 6.0 inches in the root zone at field capacity, the remaining available moisture is estimated at 50 percent. (Refer to Table 1.)

Depth of water penetration into the soil can be determined by using a soil probe, sharpshooter, shovel, or posthole digger. By using this method, you can approximate the amount of actual moisture available to the plant.

B. Mechanical Methods of Measuring Soil Moisture

GRAVIMETRIC METHOD (OVEN DRYING)

The gravimetric method consists of obtaining a moist soil sample, placing it in an oven at 105° C until it is completely dry, and then determining the percentage of moisture. The calculation would be done as follows:

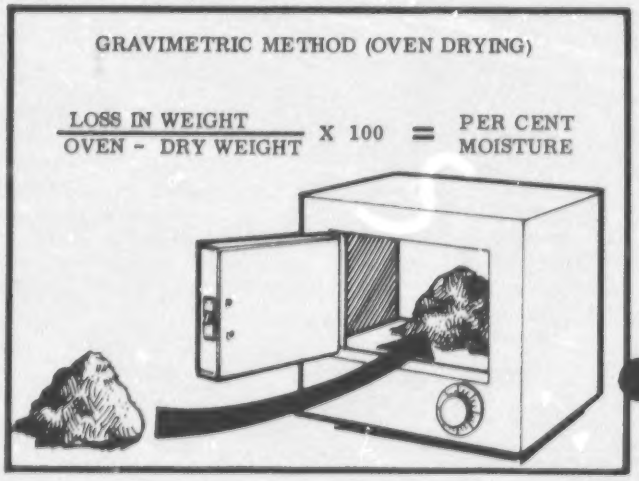


TABLE I: ESTIMATING SOIL MOISTURE BY FEEL AND APPEARANCE

Degree of Moisture	% Useful Soil Moisture Remaining	Feel or Appearance of Soils			
		Coarse	Moderately Coarse	Medium	Fine
Dry	0	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery, dry, sometimes slightly crusted, but easily breaks down into powdery condition.	Hard, baked, cracked; sometimes has loose crumbs on surface.
Low	25 to wilting percentage	Soil appears to be dry; will not form ball with pressure.*	Soil appears to be dry; will not form ball.*	Somewhat crumbly, but will hold together from pressure.*	Somewhat pliable; will ball under pressure.*
Fair	25 to 50	Soil can be formed slightly when pressed and appears to have more moisture than indicated above.	Tends to ball under pressure but seldom will hold together.	Forms ball, somewhat plastic; will sometimes slick slightly with pressure.	Forms ball; some clays will ribbon out between thumb and forefinger.
Good	50 to 75	Tends to stick together slightly; sometimes forms very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms ball and is very pliable, slicks readily if relatively high in clay.	Easily ribbons out between fingers, has slick feeling.
Excellent	75 to field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as coarse.	Same as coarse.	Same as coarse.
Too wet	Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water form on surface.

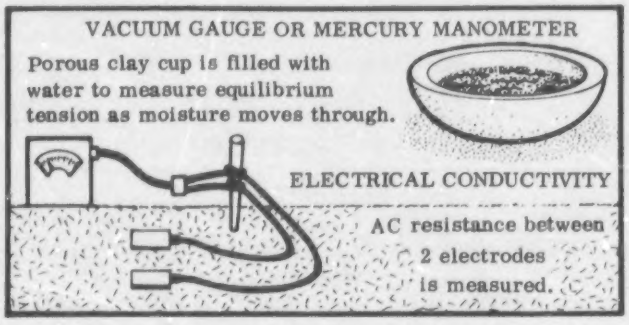
*Ball is formed by squeezing a small amount of soil very firmly in your hand.

VACUUM GAUGE OR MERCURY MANOMETER METHOD

This method depends upon measuring the equilibrium tension of soil moisture using a porous clay cup (tensiometer) filled with water. By this method, a vacuum gauge is attached to the cup, and as the soil dries out, water moves through the porous cup, setting up a negative tension or vacuum. These tension readings can then be calibrated to interpret the percentage of moisture.

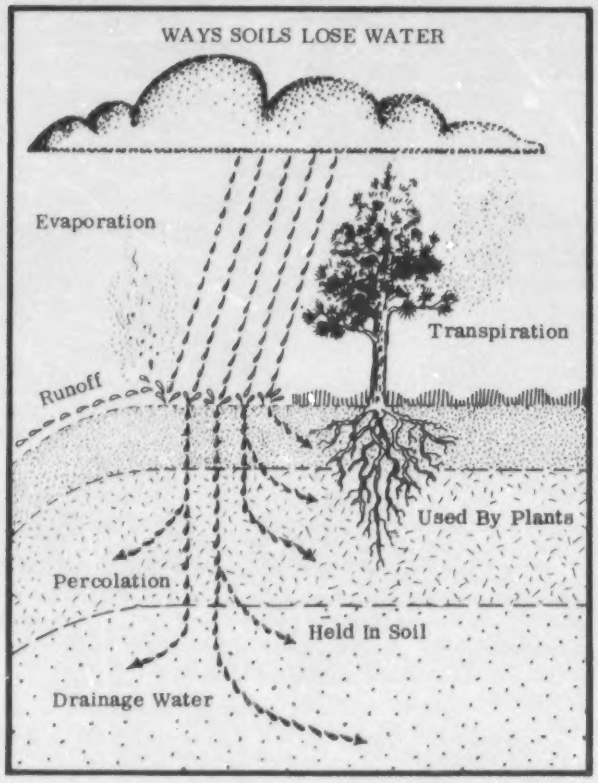
ELECTRICAL CONDUCTIVITY METHOD

The electrical conductivity method is based on changes in electrical conductivity between two electrodes in relation to changes in soil moisture. The electrodes fixed inside of blocks of gypsum, nylon, fiberglass, or other porous material are buried at a set distance apart in the soil. Wires from each block extend to the surface of the soil and are connected to a Bouyoucos bridge instrument which gives a conductivity reading that can be calibrated to percentage of soil moisture.


VACUUM GAUGE OR MERCURY MANOMETER
Porous clay cup is filled with water to measure equilibrium tension as moisture moves through.
ELECTRICAL CONDUCTIVITY
AC resistance between 2 electrodes is measured.

V. WHAT ARE THE WAYS SOIL LOSE WATER?

There are many ways that soils lose water. Some of the most important ways are runoff, evaporation, transpiration, and percolation.



A. Runoff - The amount of rainfall that enters the soil is important to the farmer. Since we are limited in our ability to modify or control rainfall, we must take it as it comes. We can, however, control <u>infiltration</u> and runoff to some extent. When runoff occurs, rainfall has exceeded in intensity and volume that amount which the vegetation and soil will absorb. Some of the factors that will affect runoff are: slope, nature of the soil, depth and condition of the soil, and the season.

The nature of the soil plays a major role in infiltration of water into the soil. The size of the pores largely depends on the size of the particles that make up the soil.

There are three ways a farmer can help to control runoff.

1. By altering the surface soil, he can increase infiltration rates.
2. He can slow down the flow of water, giving the soil more time to absorb moisture.
3. He can plan his cropping system to better utlize the seasonal rainfall in his area.

B. Evaporation - The loss of soil moisture to the air. It is the process of transforming the liquid water to a vapor. For evaporation to occur, there must be a supply of energy and a mechanism of transfer.

The sun is the source of energy which transforms water from a liquid to a vapor. Plants absorb some of the energy radiated by the sun. Some of the energy goes toward heating the air, heating the soil, and evaporating water. If there is little moisture available for evaporation, most of the radiant energy of the sun will go toward heating the air. If there is moisture available for evaporation, the energy will go toward heating the soil and evaporating the moisture.

The second factor that must be present is a mechanism of transfer. The water first is transported from the soil reservoir to the soil surface through the crop to the leaf surfaces. The water vapor is then transported from the surfaces to the atmosphere.

Evaporation is also influenced by the wind and relative humidity in the air. In areas where periods of dry weather are accompanied by strong winds, the soil tends to dry quickly. Under these conditions surface moisture is evaporated almost as fast as the soil water moves to the surface. This, in effect, thins the water films throughout the soil mass.

C. Transpiration is the omission or loss of a watery vapor from plant parts. The same condition is necessary for transpiration as is necessary for evaporation. As the soil loses water, the amount of plant transpiration decreases. The rate at which a soil will dry depends on the amount of water in the soil, the ability of the soil to give up the water, and how widely the plant roots are distributed in the soil.

Over 99 percent of water absorbed by plants is given off by transpiration. The amount of water that plants must absorb to produce a pound of dry matter varies from 250 to 1,000 pounds. This is referred to as the transpiration ratio.

In Colorado experiments, the transpiration ratio under dry climate conditions was observed to be as follows:

Crop:	(*Pounds of water for one pound of dry matter)
Millet and sorghum	300 lbs.
Corn	350 lbs.
Wheat	500 lbs.
Potatoes	630 lbs.
Clover	800 lbs.
Alfalfa	860 lbs.

*These ratios will vary from year to year and from area to area.

D. Percolation is the movement of water down through the soil. Water will move through the soil by the force of gravity until it reaches an impervious layer that will not allow it to go farther. The water will collect at this layer and supply wells and springs. Percolating waters are the only source of recharge of water for springs and wells.

The conditions which will affect percolation are texture, structure, and hard pans (compacted layers). Soils with high levels of sand and gravel will have rapid percolation, while clay soils will allow very little percolation through them. These soils may hold water at or near the surface and are sometimes called "waterlogged."

Percolation is not necessarily bad for the soil when it occurs in limited quantity. Excessive percolation will cause a loss of both water and nutrients from the soil which will hinder plant growth. Percolation should not be prevented, but controlled by farmers.

VI. HOW IMPORTANT IS GOOD DRAINAGE?

A. What is soil drainage?
Soil drainage, as a natural condition of the soil, refers to the frequency and duration of periods when the soil is free of saturation. Whether a soil is said to have good drainage or poor drainage is determined by the rapidity and extent of the removal of water from the soil by runoff and by percolation through the soil.

Originally, about 216 million acres or one-fourth of the nation's potential agricultural land was too wet for farming. Many acres of this highly productive crop and pasture land have been placed in production after establishing drainage systems, and many poorly or improperly drained areas would be very productive if they were drained. Of the approximately 1.1 billion acres in farm land in 1970 about 100 million acres are located in drainage areas.

As the population of the world increases, it will be necessary to increase agricultural production to meet the demands. One way of accomplishing increased production is to provide drainage for areas with excessive water.

Drainage is also a method of conserving and controlling water and should be a part of every conservation program.

B. What are some benefits resulting from proper drainage of wet soils?
According to the Census Bureau's population projections, there will be between 236 and 277 million people in the U. S. by 1985. It is estimated that this population will be using 90 percent of the country's available water supply. To continue to grow and maintain our standard of living, this country must establish measures of conserving water; and drainage can be a part of this conservation plan.

The bottomlands which are generally wet soils often have the most fertile soils on the farm. Because they are excessively wet at times through the year, they produce only part of the yield they could produce with proper drainage.

A wet soil is a colder soil than dry soil. This is because it takes five times more heat to raise the temperature of water one degree than is required for dry soil. Well drained soils warm earlier in the spring and permit earlier planting of crops.

Plants normally grow better in warm soil where there is air in the root zone. When soil is drained, the excess moisture in the soil is replaced by oxygen which increases beneficial bacterial activity.

Soil structure is improved by drainage. A wet soil is likely to be tight or compact and most plant roots cannot grow readily in tight soils. Also, the drying process accelerates the growth of bacteria and fungi and increases earthworm activity, all of which aid in creating more desirable soil structure.

Drainage allows deeper penetration of plant roots which increases the availability of soil nutrients, thus resulting in greater yields.

Well-drained soils permit more efficient utilization of lime and fertilizers.

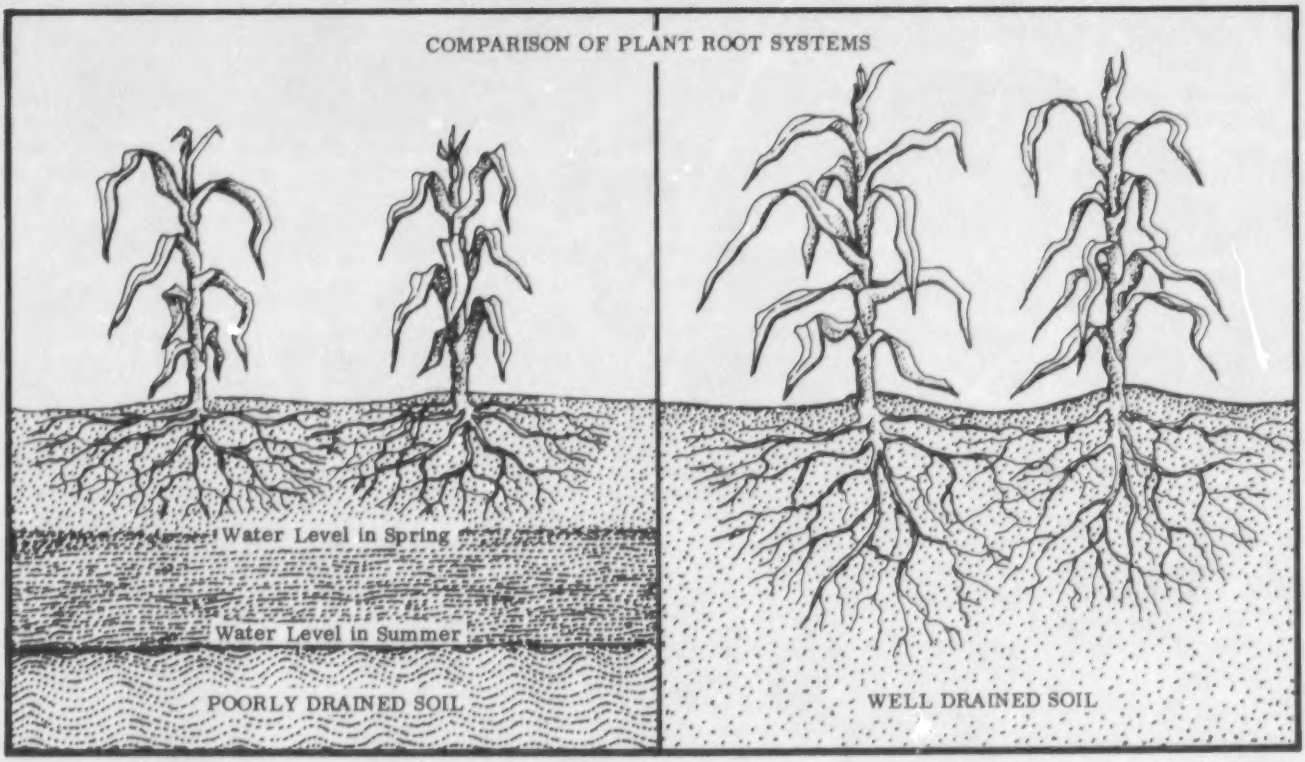
Drainage decreases the losses of nitrogen from the soil, thus increasing the percentage of crude protein in plants. It also increases the percentage of potassium, chlorine, and magnesium in plants.

Drained croplands are freer from certain diseases, while drained pasturelands are less infested with parasites.

A wider variety of crops can be grown on properly drained soils.

Proper drainage makes for earlier and more efficient tractor operations. It allows field operations to begin sooner after rains, planted seeds will germinate faster resulting in better stands, and crops can be harvested earlier.

An example of the benefits of proper soil drainage is shown in the illustration below of comparing a poorly drained soil and a well-drained soil. The plant roots in the poorly drained soil are shallow and spread out near the surface. This occurs because of the excess water near the surface in the spring and the compactness of the soil. Then as



the water level drops below this root zone in the hot, droughty summer months, the crops "burn out" because the plants are not getting enough moisture. In well-drained soil, plants develop a more extensive root system which obtains water and nutrition from a larger volume of soil. The roots grow deeper into the soil, thus permitting the plants to better withstand summer droughts.

VII. NATURE OF DRAINAGE AND WATER PROBLEMS

A. Poor drainage in soils may result from overflow flooding, the catching of hillside run-off in low-lying flat land, return flow seepage on sloping land, restricted subsoil drainage, the accumulation of excess water in low areas, and a build up of the water table.

B. Drainage problems fall into four main categories:

Economic - To determine whether the benefits of drainage would be economically feasible, the landowner should determine the cost of providing drainage and estimate returns.

Agronomic - These considerations include the probable productivity of the acreage after drainage, adaptability of proposed crops, and additional expense and investment required in the new cropping system(s).

Mechanical - These considerations include such things as location and type of outlets for the main volume of runoff, size and type of drains required, grade and possible damage to other structures.

Legal - The planning of drainage systems frequently raises questions of legality, so legal considerations should be a part of the overall plan.

VIII. SOIL CONDITIONS THAT REQUIRE DRAINAGE

A. Permeability and Drainage

Soils that characteristically have a slow downward movement of water often need artificial drainage because of excess surface water. (Permeability is the capacity of a soil profile to allow movement of air and water through it.) Slowly permeable soils often require artificial drainage in situations where the land surface is level and rainfall is high causing excess surface water. Soil drainage experiments in high rainfall areas have indicated that fine-texture of soils with massive structure are most in need of artificial drainage.

Permeable soils that generally do not require drainage are identified by a uniform color varying from brown to red throughout the profile. Yellow shades of subsoil indicate intermediate permeability, while clay subsoils that are gray in color are usually very slowly permeable and need artificial drainage.

B. Drainage and Ground Water Levels

A permeable soil seldom needs artificial drainage,

except when the soil has a high water table. High water tables are most common in low-lying sandy soils and peat and muck soils.

Ground water table - The average depth of the ground water table is an important factor to consider in soil drainage and should be determined by the landowner. The ground water table is the distance from the surface of the ground to the water surface in an open hole. Generally, the ground water table, depending on the area and climatic conditions, varies from ground level to fifteen feet in depth; however, it may be much deeper in parts of Texas. The ground water table, often referred to as the "perched" water table, is not related to the deeper layers of water; and the two are separated by impervious or slowly pervious subsoils. The depth of the ground water table is a major factor to be considered by the farmer as he determines the drainage system to install on his farm.

Providing drainage will affect only the free or surplus water and will not disturb or reduce the capillary water, which is necessary for plant growth. The opinion expressed by some that an area can be over drained is not ture.

Recharging underground water - The proper amount of water is always a problem of farmers and ranchers-either there is too much moisture or not enough. Seldom are moisture conditions ideal; however, they can be improved by proper management. One of the most effective methods that can be used to dispose of excessive water and at the same time conserve water is to recharge the underground water supply.

The underground water supply, according to U.S.D.A. Research Agricultural Engineers at Bushland, Texas, is being depleted rapidly by withdrawal of water to irrigate several million acres of crops each year. During the decade from 1958 to 1967, it was estimated that water storage was reduced by 35 million acre-feet to 125 million. Exhaustion of underground water is a major concern today. On the High Plains of Texas, average annual recharge in the Ogallala Formation (the major underground water source) is only one-half inch yearly, while pumpage has averaged 5 million acre-feet. Many communities throughout Texas have already had to dig more wells, and some communities and cities have had to supplement their water supply by building lakes. In order to safeguard the present underground water supply, it is very important that recharge water not be contaminated.

Several methods of recharging have been studied, and it appears that the most successful method is the use of wells. However, recharging with a pit recharge has possibilities. Another possible method of recharging the underground water supply is the spreading of water. This method may be used in areas of low rainfall and in soils that are capable of permitting the water ready access to underground storage.

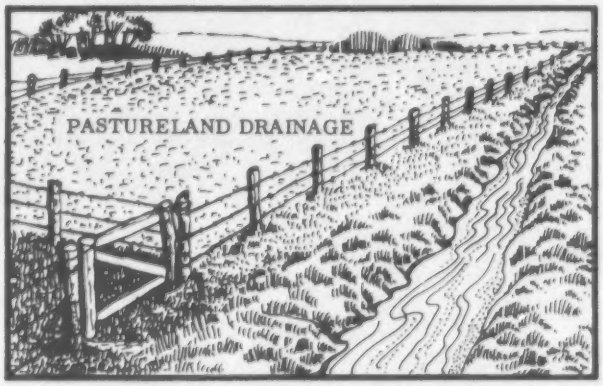
IX. DRAINAGE SYSTEMS

The two main types of drainage are surface or open ditch and subsurface or underground. The system to use will be determined by the permeability of the soil, slope of the land, cover or vegetation of the area to be drained, average depth of water table, topography, and stratigraphy.

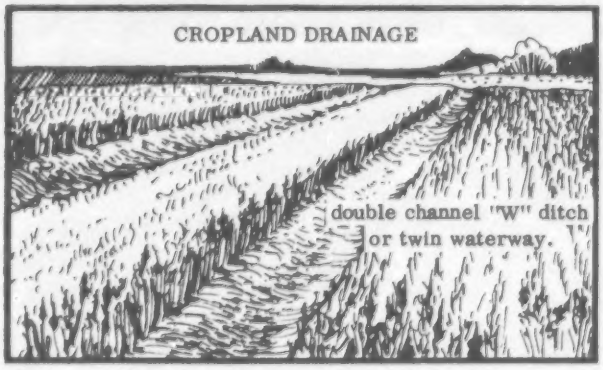
A. The major systems of surface drainage include:

Open Ditch Drainage
This system is probably the most used and least expensive. The farmer should keep in mind that surface ditches remove only water on the soil surface and not the water in the soil. Also, the water intake rate of the soil should be kept as high as possible so that water which could be stored will not be drained off. Otherwise, when rains are not frequent, the soils will become too dry. If this system is used, the ditch should be sodded to prevent erosion.

Pastureland drainage is sometimes needed to remove excess water in order to establish desirable grasses or carry out other improvement practices on the land.



Surface drainage of croplands may be accomplished by several methods; however, the double channel field ditch system is commonly used to remove surface water from cultivated fileds.



The W-ditch drainage method as shown in the illustration has some advantages over other field drainage systems. The advantages of the W-ditch are:

1. Can be constructed and maintained with ordinary farm equipment,
2. Allows better row drainage because spoil does not have to be spread,
3. May be seeded to grass or planted to row crop,
4. May be used as a turn row, and
5. May serve as a field road.

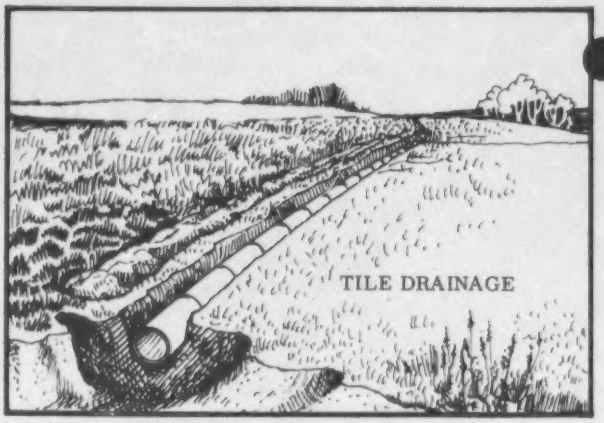
The minimum spacing for the W-ditches varies from about 15 to 50 feet, depending on the size of the drains. The W-ditch is best adapted to flat land where the rows drain toward the ditch from both directions.

Diversion Ditches
This is a form of open ditch drainage that is used on sloping fields. It may be necessary to construct more than one diversion ditch in a field to handle surface water.

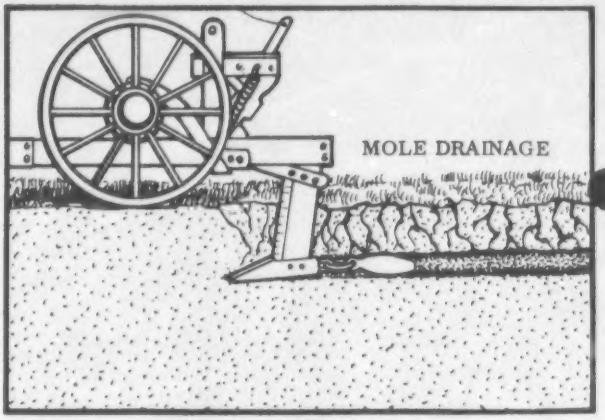
Terraces and Contours
Still another open ditch drainage system includes terraces and contours. These are used to remove water before it becomes a problem on crop land and pastures.

B. Types of subsurface drainage systems are:

Tile Drainage
This system is not widely used in Texas, possibly because of the expense involved; however, it is an effective means of draining water. Using tile drainage, the farmer places either 12 or 24 inch tile at a depth of three to six feet. The depth is determined by the amount of water to be drained, the permeability of the soil, the possibility of salt accumulation in the soil, and other factors. It is not necessary to lay several lines of tile to drain most areas.



Mole Drainage
A cylindrical channel or mole drain is formed by pulling a ball or bullet shaped device through the soil at the bottom of a narrow blade. Mole drains are unstable and are dependent upon the stability of the soil to maintain an open channel. Mole drains have been used successfully in some areas.



GLOSSARY OF TERMS

1. Wilting point - The moisture content of soil at which plants wilt and fail to recover when placed in a dark humid atmosphere.

2. Infiltration - The downward entry of water into a soil. Infiltration rate denotes how rapidly a soil will absorb water.

3. Inpervious - A soil that will not absorb water or through which plant roots cannot penetrate.

4. Water table - The upper part of the soil and underlying rock material that is saturated with water.

5. Pit recharge - The draining of excess water into a large pit; the pit must permit the water to enter the underground storage area.

6. Topography - The shape of the ground surface as determined by such major features as hills, mountains, or large plains. "Steep" topography and "flat" topography are examples of terms commonly used to indicate slope of the land.

7. Stratigraphy - The arrangement of the soil strata.

8. Spoil - Soil or rock material removed from a canal, drainage ditch, diversion, or similar construction.

SUGGESTED STUDENT ACTIVITIES

1. List some of the ways that soil water serves plants.
   a.
   b.
   c.
   d.

2. Look at the illustration on page 2, which shows the rainfall distribution in Texas. Now, what is the average rainfall for the county in which you live as shown on the map?
   County _____
   Rainfall _____

3. Explain the differences in the three types of soil waters: capillary, hygroscopic, and gravitational.

4. What are some methods used for measuring soil moisture?
   a.
   b.
   c.
   d.

5. List the most important ways that soils lose water.
   a.
   b.
   c.
   d.

6. Give five benefits that result from good soil drainage.
   a.
   b.
   c.
   d.
   e.

7. What are some soil conditions that typically require drainage?

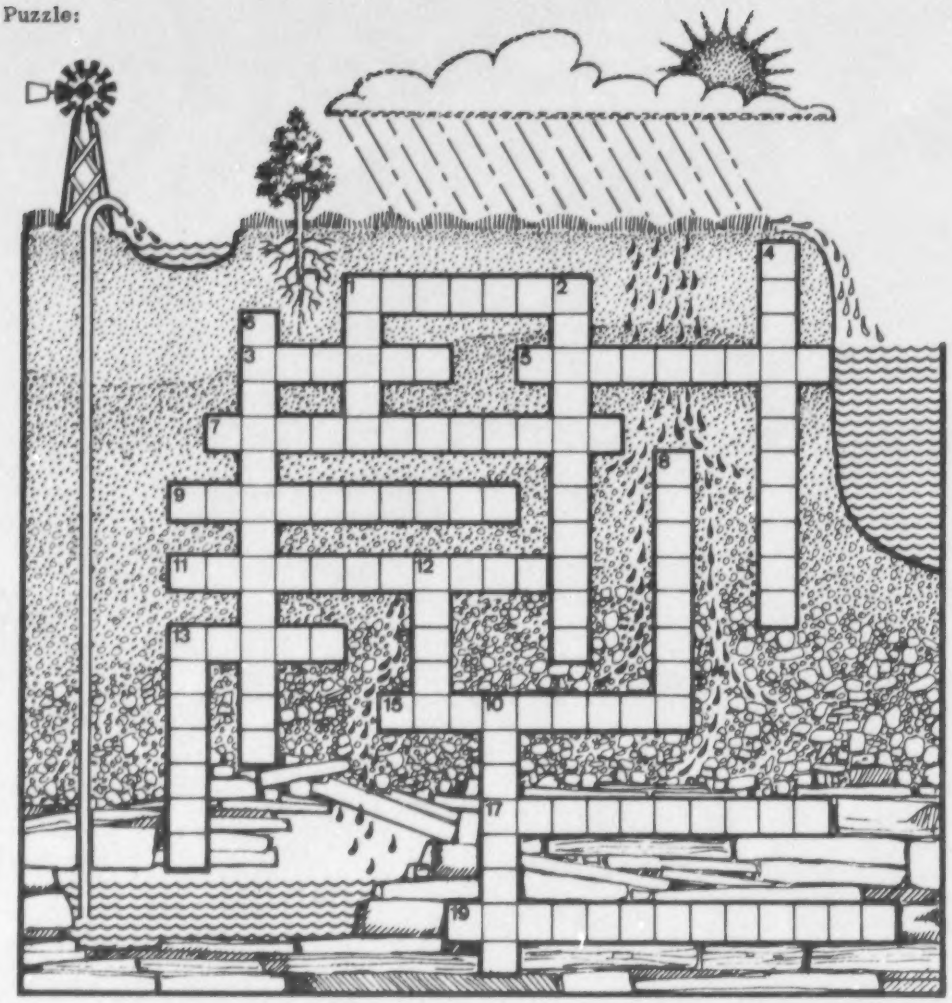
8. List the two main types of drainage systems and give examples of each.
   a.
      1.
      2.
   b.
      1.
      2.

9. Match the following statements or terms with the responses that are given below:

a. Gravitational water	____ Procedure for measuring soil moisture
b. Infiltration rate	____ Movement of water down through the soil
c. Runoff	____ Free or excess water in the soil
d. Percolation	____ Water lost on the surface of the soil
e. Water table	____ Denotes how rapidly a soil will absorb water
f. Open ditch drainage	____ The distance from the surface of the ground to the water surface in an open hole
g. Subsurface drainage	____ A system for draining surface waters
h. Topography	____ Loss of soil moisture to the air
i. Evaporation	____ Underground water drainage
j. Gravimetric method	____ Shape of the ground surface which affects water removal from soils

10. Describe the greatest problem with soil water losses in your surrounding community.

11. Crossword Puzzle:



Across:

1. Terraces are a form of _ _ _ _ _ _ _ drainage.
3. Excess rainfall that is not absorbed by the soil
5. Water that adheres to soil particles
7. Downward entry of water into a soil
9. Describes a soil that will not absorb water
11. The movement of water down through the soil
13. The distance from the surface of the ground to the water surface in an open hole is _ _ _ _ _ table.
15. Soils that generally do not require drainage are said to be _ _ _ _ _ _ _ _ _.
17. Tile drainage is a type of _ _ _ _ _ _ _ _ _ _ drainage.
19. Free or excess water in the soil

Down:

1. Soil material or rock removed from a canal, drainage ditch, etc.
2. Loss of soil moisture to the air
4. Water tightly held by soil particles not available for plant growth
6. Loss of water from plant parts
8. Soil _ _ _ _ _ _ _ _ is determined by the extent and rapidity of the removal of water from the soil.
10. Soil _ _ _ _ _ _ _ _ is the water content of the soil.
12. Depth of ground water _ _ _ _ _ aids in determining the choice of drainage systems.
13. _ _ _ _ _ _ _ _ point is reached when plants begin to show visible deterioration due to lack of soil water.

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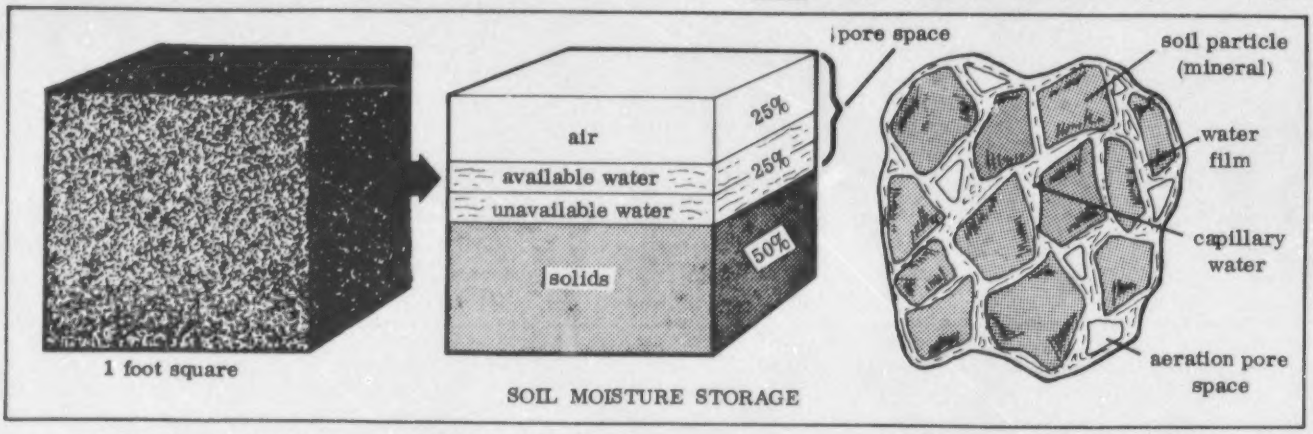
176

WATER REQUIREMENTS OF CROPS

I. SOIL MOISTURE STORAGE

The soil serves as a storage reservoir for moisture. It is partly solid and partly space. On a volume basis, the soil is about half solid material and half pore space,* the pore space being occupied by water and air.

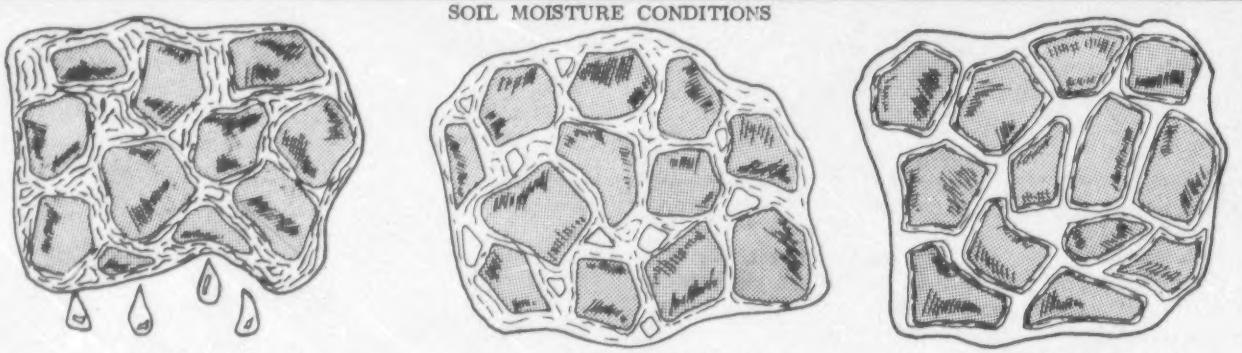


SOIL MOISTURE STORAGE

A cultivated loam soil in good physical condition is comprised of approximately 50% solids and 50% pore space as shown by this illustration. Under ideal moisture conditions, the pore space would be comprised of about 25% air and 25% water. Only half of this water would be available for plant use, thus about one-eighth of the equivalent soil volume contains available water.

The mineral particles making up the solid portion of the soil are of many sizes touching each other only at certain points. The pore space not occupied by these particles will vary as to percentages of air and water. Water stored as soil moisture, which is available to the plants, is retained in the form of wedges at the point of contact and as thin films around each of the soil particles. The water is held around the soil particles by surface tension forces against the pull of gravity.

SOIL MOISTURE CONDITIONS

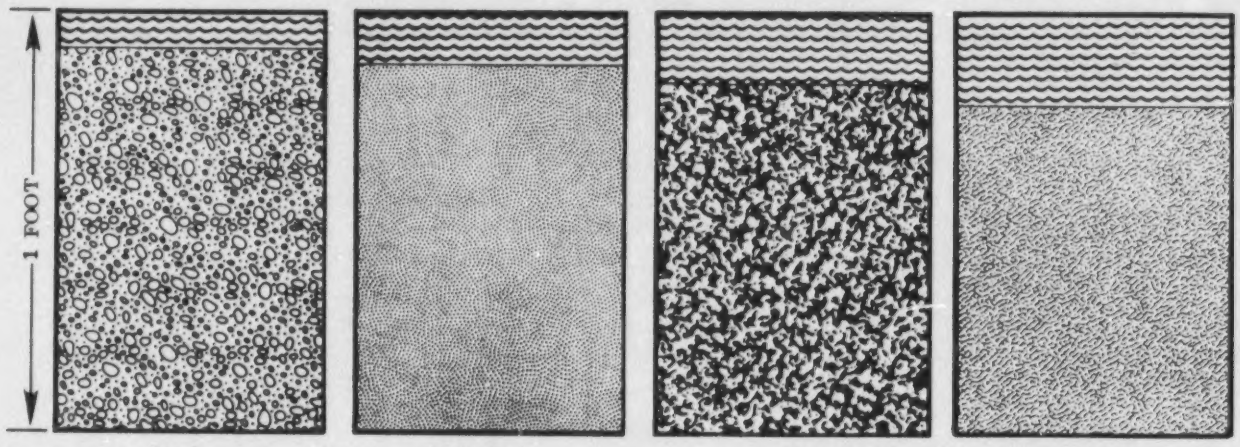


Saturation (too wet) | Field Capacity (ideal) | Wilting Point (too dry)

As already indicated, water is held in soils as thin films around the soil particles. On a saturated soil, all the pore spaces are filled with water, and the soil will remain "too wet" if the water is not allowed to drain from it. Ideal moisture conditions generally exist only when there is approximately 25% air and 25% water. Under this ideal moisture condition, only half of this water is available for use by plants. As this moisture is used, the tension holding moisture to the soil particles becomes so great that the plants no longer can obtain water. When this moisture condition is reached, the plant permanently wilts. If the water supply is not soon replenished, the plant will die.

*Underlined terms are defined in the "Glossary of Terms."

AVAILABLE MOISTURE STORAGE CAPACITY
FOR VARIOUS TEXTURED SOILS
PER FOOT OF DEPTH



II. THE SOIL-WATER-PLANT RELATIONSHIP

Plants live primarily on a liquid diet. Water constitutes about 75 to 90 percent of the fresh weight of growing plants. Water carries mineral nutrients and gases into the plant roots from the soil. If we understand the basic principles of water storage and movement in the soil, we may solve the problem of supplying crops with necessary water for productive growth.

Water is important in the cooling and bathing of the internal tissues of plants so that carbon dioxide may be absorbed which will help dissolve soil nutrients used by the plant itself.

Water bathes the cells continually within the plant. This assists the movement of elements needed throughout the plant.

The hydrogen content in water is also considered an important part of the compounds formed in water.

The soil serves as a storage reservoir for water. When water is in the root zone, plants can secure the water requirements needed for proper growth and development. As the plants continue to use water, the available supply diminishes, and the plants finally stop growing unless more water is added.

III. SOME FACTORS WHICH AFFECT THE WATER AVAILABILITY TO PLANTS

The amount of water that can be stored in the soil and used by the plants depends upon the depth of soil occupied by the active root system of the plant and profile characteristics of the soil such as texture and structure.

Fine-textured soils have more particles and more surface area than coarse-textured soils. Therefore, more water may be stored in fine-textured soils than in coarse-textured soils.

Because there are more particles of smaller size in clay soils than in sandy soils, the fraction is larger for clays and smaller for sands. Table 1 shows the approximate available water storage per foot of depth for various textured soils.

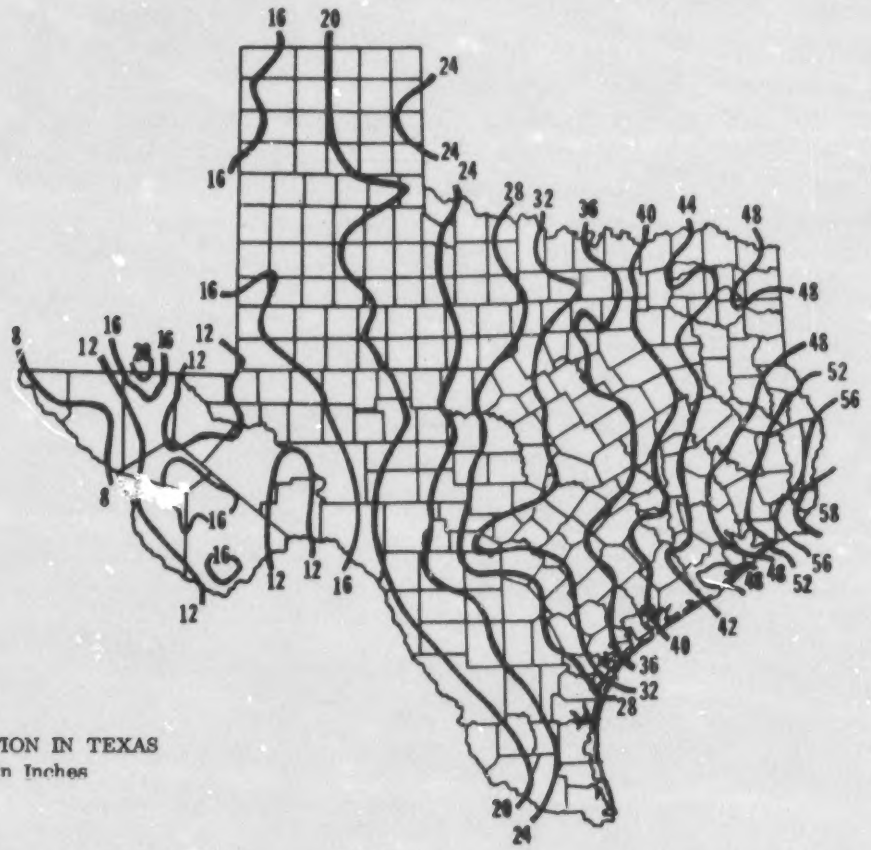
TABLE 1: Approximate Available Water Storage Capacity of Soils

Soil Texture	Approximate Water Inches Per Foot Depth
Sands (coarse)	½ to 1
Sandy Loams (medium)	1 to 1½
Silt & Clay Loams (medium)	1½ to 2
Clays (fine)	2 to 2½

The amount of water available to plants will also be influenced by the temperature, amount of sunshine, and rainfall in the area.

The southern part of the United States has large amounts of rainfall; however, the distribution is not uniform.

Texas has a wide variation in the amount of rainfall. This extreme rainfall variation will have a great influence on the type of crops grown throughout the state. Crops grown in the western section of the state will usually be (except in irrigation areas) those that require the least amount of moisture to produce them. Many of the crops grown in the eastern section of the state will require large amounts of moisture.



RAINFALL DISTRIBUTION IN TEXAS
Amounts Given in Inches

IV. SOME FACTORS WHICH AFFECT THE WATER REQUIREMENT OF PLANTS

A. Of all the materials used by the plant for its growth and maintenance, water is taken up in the largest amount. The total quantity of water removed from the soil by a growing plant is large in comparison to the amount present in the plant at any one time. The bulk of the water absorbed by the plant through the roots is not retained but evaporates into the air from the leaves. This water loss by evaporation is known as <u>transpiration</u>.

The amount of water required by various crops to produce a pound of dry matter is known as the transpiration ratio. Transpiration ratios vary depending on location and climatic conditions. In general, more water is transpired by plants grown in hot, dry climates than under cool, moist conditions. Considerable variation exists among different species of plants in the amount of water required for normal growth.

TRANSPIRATION RATIO
Amount of Water Required to Produce One Pound of Dry Matter

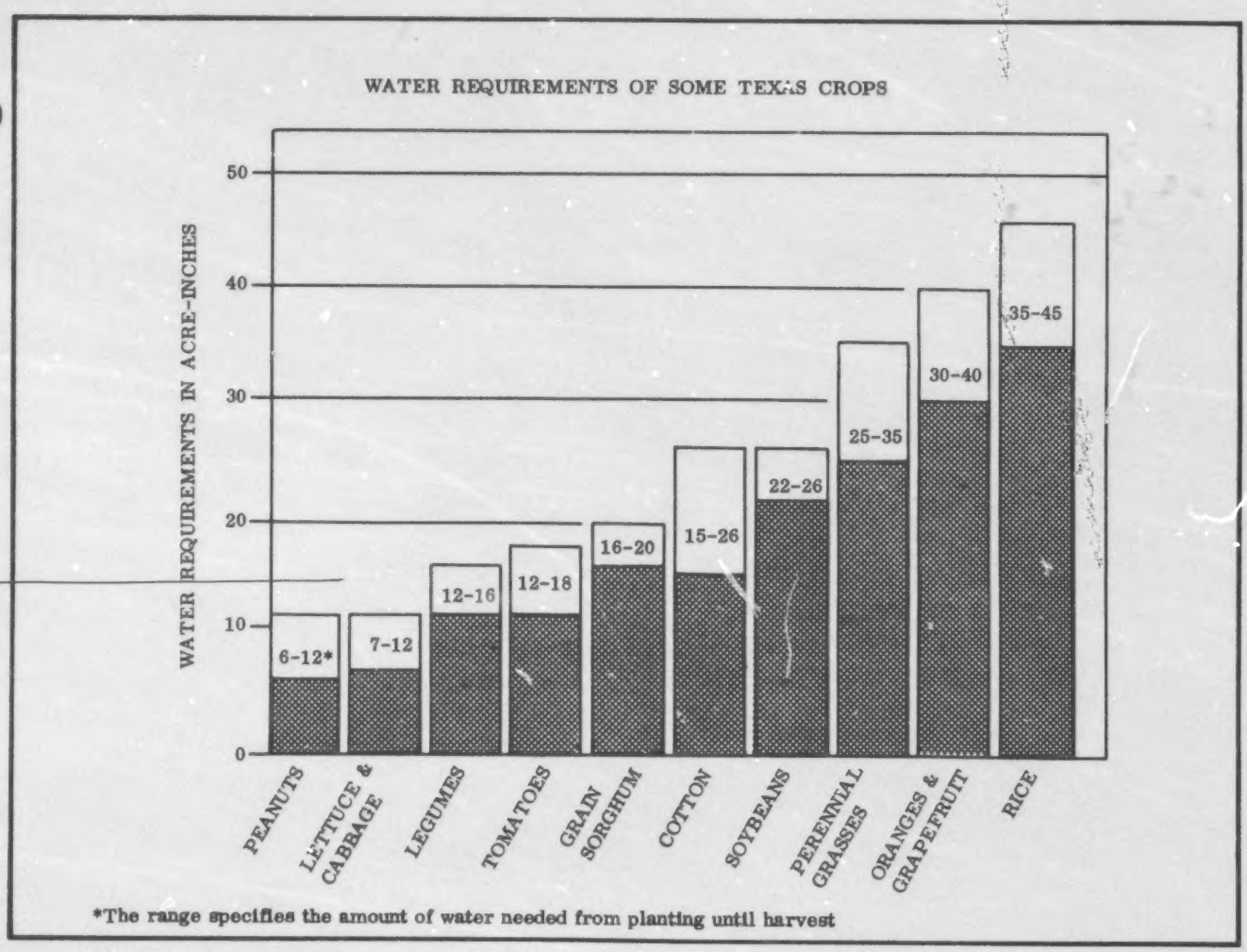
CROP	AMOUNT OF WATER
ALFALFA	860 lbs.
CLOVER	800
CORN	370
GRAIN SORGHUM	300
OATS	600
POTATOES	630
SOYBEANS	770
WHEAT	500

B. The water requirement of individual crop plants is greatly influenced by prevailing climatic conditions. As already stated, plants grown in hot, dry climates transpire more than plants grown under cool, moist conditions. For example, the same crop grown under different climatic conditions will require differing amounts of water to produce the same yield.

C. The fertility of the soil will affect the amount of water used by plants in their growth. Because yields are higher on fertile soils, the total water requirement for plants grown on fertile soils is greater than for plants grown on relatively infertile soils. However, per unit of production,

TABLE 2: WATER REQUIREMENTS OF TEXAS CROPS

CROP	CRITICAL WATER DEMAND PERIODS	APPROXIMATE WATER USE IN INCHES PER DAY	WATER REQUIREMENT INCHES
COTTON	BLOOM STAGE UNTIL ABOUT 1/2 TO 3/4 OF BOLLS ARE MATURE	0.25 - 0.40	15 - 26
CORN	TASSELING-SILK STAGE UNTIL GRAIN BECOMES FIRM	0.20 - 0.28 0.28 - 0.38	8 - 12 HUMID 15 - 22 SEMI-ARID
GRAIN SORGHUM	BOOT, BLOOM, AND MILK-DOUGH STAGES	0.25 - 0.40	16 - 20
WHEAT-SPRING	BOOT, BLOOM, AND EARLY HEAD STAGES	0.22 - 0.35	14 - 22
TOMATOES	BLOOM AND FRUIT ENLARGEMENT PERIOD	0.25 - 0.35	12 - 18
LETTUCE AND CABBAGE	HEAD FORMATION UNTIL THEY BECOME FIRM	0.17 - 0.20	7 - 12
IRISH POTATOES	TUBER SWELLING PERIOD	0.16 - 0.20	12 - 15
CARROTS	WHEN ROOT ENLARGEMENT AND SWELLING STARTS	0.15 - 0.19	8 - 10
ONIONS	BULB FORMATION TO MATURITY	0.15 - 0.20	10 - 12
ALFALFA	BLOOM AND SEED FORMING	0.27 - 0.40	30 - 50
SOYBEANS	BLOOM AND SEED FORMATION	0.25 - 0.35	22 - 26
CASTOR BEANS	BLOOM STAGE TO PHYSIOLOGICAL MATURITY	0.33 - 0.40	25 - 30
PEANUTS	PRIOR TO AND DURING TIME NUTS START TO FORM	0.22 - 0.25	6 - 12
PERENNIAL GRASSES	SEED HEAD FORMATION	0.25 - 0.35	25 - 35
LEGUMES	BLOOM & SEED FORMING-SUMMER BLOOM & SEED FORMING-WINTER	0.22 - 0.33 0.13 - 0.19	15 - 24 12 - 16
RICE	HEAD FORMATION & FILLING	0.25 - 0.30	35 - 45
PEACHES	FRUIT SETTING & FRUIT SWELLING	0.22 - 0.26	22 - 30
ORANGES AND GRAPEFRUIT	FRUIT SETTING & ENLARGEMENT STAGES	0.25 - 0.35	30 - 40



*The range specifies the amount of water needed from planting until harvest

the plants grown on fertile soils make much more efficient use of water than those grown on poor soils.

D. The growing season and growing habits of the plants will affect the water requirement of various crops because the demand periods and seasonal requirements will vary considerably.

E. The type of root system is another factor that will determine the amount of water required for any given crop. The two types of root systems of plants are fibrous roots and taproots. Some examples of these types of root systems are:
   1. Fibrous—corn, oats, wheat, and grasses.
   2. Taproot—cotton, beans, and tobacco.

The crops listed above are only a cross-section of the different ones grown throughout the state.

The periods are based on the stage of growth in which a lack of soil moisture probably would be most detrimental to yield or quality or both.

Daily evapo-transpiration rate (approximate). These are expected average maximum daily water use values for the individual crops. Generally, the periods of maximum water use for most crops will be during the bloom and fruiting stages of growth. In some cases it may extend about half through the maturing stage. Because of the wide variation in climate, soils, crops, varieties, and planting dates throughout Texas, these values are somewhat general.

The water requirement values shown are usually the extremes which can be expected. Also remember that the total amount of water specified is the requirement from time of planting until complete production of the crop. For ideal conditions, this water must be available only in certain portions of the total amount through the development and production of the crop. Remember that the water-holding capacity of the soil will cause some areas to require more moisture than others. The smaller requirement inches apply to the more humid regions, while the larger requirement inches are to be applied to the semi-arid regions of Texas. When saline soils and water are encountered, the requirement will be increased 20 to 50 percent and even more in such areas as the Transpecos.

GLOSSARY OF TERMS

1. Pore space - Total space not occupied by soil particles in a volume of soil, commonly expressed as a percentage. Percent pore space is equal to

$$100 - \frac{\text{Bulk Density}}{\text{Particle density}} \times 100$$

2. Saturated soil - A soil at the point that it does not have the capacity to absorb and hold any more water without losing an equal amount.

3. Permanent wilt - The water content of soil on an oven-dry basis at which plants wilt and fail to recover their turgidity when placed in a dark humid atmosphere. Permanent wilt exists when plants remain in a wilted stage day and night.

4. Transpiration - The process by which water vapor is released to the atmosphere by the leaves or other parts of a living plant.

5. Fibrous roots - Plant roots having a large number of finely divided, widely spreading roots but no large individual roots.

6. Taproots - Some plants have a large single "taproot" normally growing straight down, from which most of the smaller roots spread out laterally.

SELECTED STUDENT ACTIVITIES

1. Fill in the blank(s) in the statements below with the best choice of word(s) from those provided.
   a. A cultivated loam soil in good physical condition is made up of approximately _____ percent solids and _____ percent pore space.
   b. Under ideal moisture conditions, the pore space would be comprised of about _____ percent air and _____ percent water.
   c. Water constitutes about _____ to _____ percent of the fresh weight of growing plants.
   d. _____ soils have more pore space for water storage than _____ soils.
   e. Water loss in plants by evaporation from the leaves is known as _____.
   f. Type of root system affects the amount of water required for a crop. For example, corn which has a _____ system will have a different water requirement than cotton which has a _____ system.
   g. The water requirement for some crops grown in Texas climatic conditions will vary as follows:
      (1) Peanuts, _____ to _____ acre inches
      (2) Tomatoes, _____ to _____ acre inches
      (3) Grain sorghums, _____ to _____ acre inches
      (4) Soybeans, _____ to _____ acre inches
      (5) Rice, _____ to _____ acre inches
      (6) Oranges and grapefruit, _____ to _____ acre inches
      (7) Legumes (winter), _____ to _____ acre inches
      (8) Perennial grasses, _____ to _____ acre inches

Transpiration	75/90%	6 - 12 in.
Clay	50/50%	16 - 20 in.
Sandy	25/25%	22 - 26 in.
		25 - 35 in.
Fibrous root	12 - 16 in.	30 - 40 in.
Taproot	12 - 18 in.	35 - 45 in.

2. List some other factors which affect the water requirements of plants.
   a.
   b.
   c.
   d.

3. Look at the illustration showing "Rainfall Distribution in Texas" and record below the average rainfall shown for the county in which you live.
   County _____
   Average Rainfall _____

4. List the crops that are suited to growing conditions in your home county and compare the water requirements of these crops to the average rainfall for the county.
   a.
   b.
   c.
   d.

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SOIL & WATER CONSERVATION MEASURES

I. CHARACTERISTICS AFFECTING THE MANAGEMENT OF SOIL WATER

There are three basic problems relating to characteristics of soil water which the farmer or rancher must consider in the management or conservation of soil water: (1) increasing water entry into the soil, (2) improving soil water movement, and (3) increasing water storage capacity.

A. Increasing Water Entry into the Soil

What really counts in a rain is how much of it enters the soil.

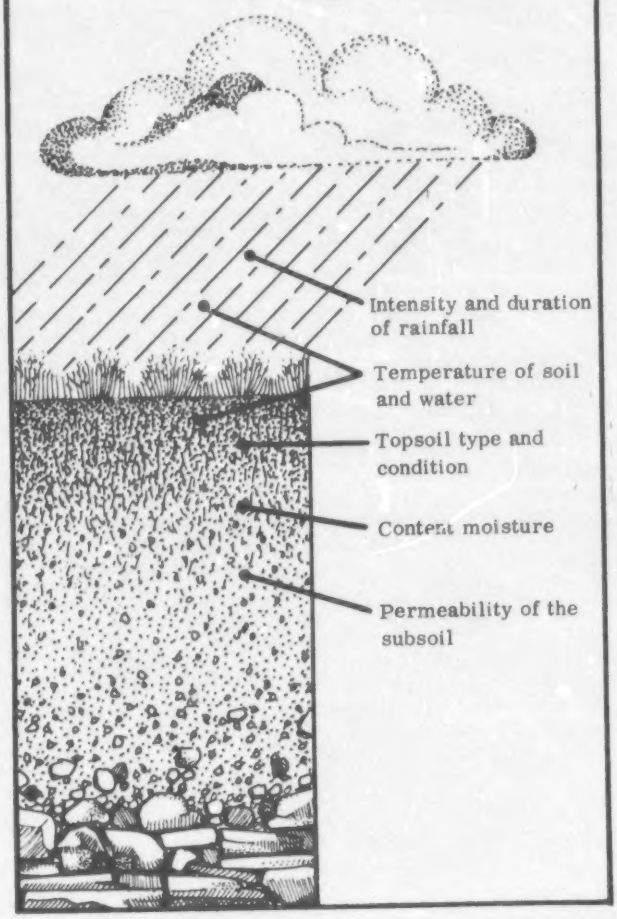
There are five major factors that affect intake of water by the soil.

1. The duration of rainfall or application of water
2. The season of the year and temperature of soil and water. Infiltration* tends to be higher in the warm months than in the cool months.
3. Surface condition and amount of protection against the impact of rain. Rain on bare soils breaks up soil aggregates, leaving a compact, dense surface layer which slows movement of water into the soil.
4. The moisture content and degree of saturation
5. Internal characteristics of the soil mass, including pore size, depth or thickness of the permeable portion, degree of swelling of clay particles, content of organic matter, and degree of aggregation. Soil characteristics that primarily govern infiltration are the physical properties like texture and depth to the slowly permeable horizons. Some of the highest rates of infiltration occur on deep sands or on deep silt loam soils that are highly aggregated and therefore have relatively large pores. Clay soils with a high degree of swelling when wet can be expected to have a much lower rate of water intake.

The illustration above shows the factors that affect the infiltration of water into the soil. These same factors are related to the amount of rainfall that runs off and may cause erosion.

Of the five factors mentioned, the ones readily modified by man's action are those dealing with the surface condition of the soil and its protection against rain impact. An ideal soil allows water to enter as rapidly as it rains under normal conditions.

FACTORS AFFECTING SOIL INTAKE OF WATER

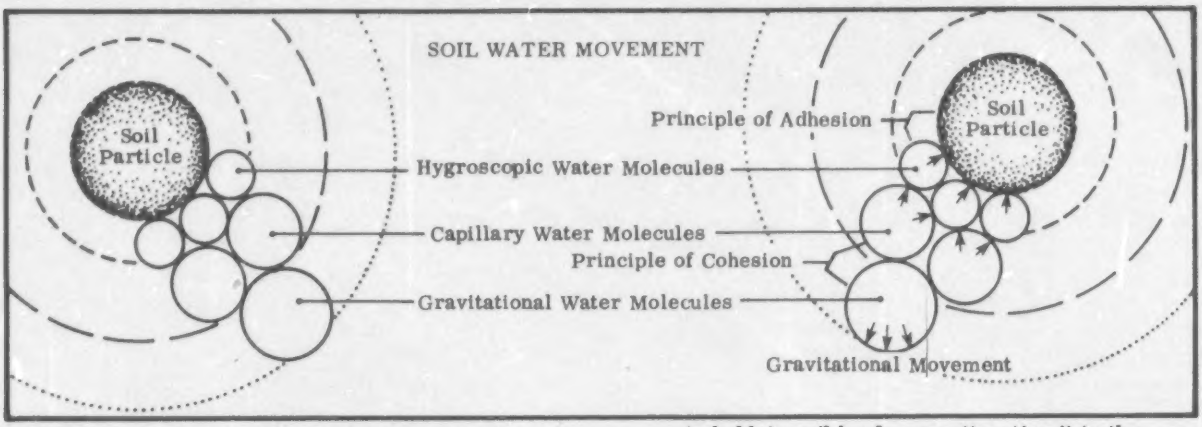

Intensity and duration of rainfall
Temperature of soil and water
Topsoil type and condition
Content moisture
Permeability of the subsoil

B. Improving Soil Water Movement

Soil water movement is mainly controlled by such factors as soil structure, aeration (air spaces), and the behavior of soil water in relation to soil particles.

As water is held in capillary spaces between soil particles or aggregates and as films on their surfaces, the soil pores (air spaces) provide passages for plant roots, air, and water.

*Underlined terms are defined in the "Glossary of Terms."



Though gravity moves soil water downward, the forces between soil particles and water molecules act without regard to direction. Gravitational water is free to move downward under the force of gravity. Capillary water may move in any direction in response to capillary tension. Both gravitational water and capillary water can be removed from the soil by plant roots. Hygroscopic water has no movement and is unavailable for plant use.

Soil moisture is attracted to soil particles much as steel particles are attracted to a magnet. The water film closest to the soil particle is held with enough tension that it is unavailable to plants. As the water layer on the soil particle becomes thicker, the water near the outside of the layer is not as strongly attached to the soil particle.

The behavior of soil water in relation to soil particles, then, can be explained on the basis of adhesion and cohesion. Adhesion in this case is the force that attracts molecules of water to molecules of soil. Cohesion is the force that attracts molecules of water to one another. Water molecules at the outside of thicker water layers move away to water layers that are thinner. Thus, water molecules are attracted to soil particles directly by adhesion and indirectly by cohesion.

There is a tendency for water to move from areas where the water films are thick to areas where they are thin. This causes water to move into a dry soil. Water moves more rapidly when moisture films are thick, but as the films become thinner, the rate of movement slows. As this drying takes place, water does not move over a fraction of an inch to provide moisture to plant roots. Thus, plant roots must be well distributed through the soil to make maximum use of soil moisture.

C. Increasing Water Storage Capacity

The major factors affecting water storage capacity are texture, structure, and organic matter.

Texture - As we have already discussed, water is held in soil by forces attracting it to the surface of the soil particles; therefore, the greater the surface area of soil particles, the more water the soil will hold. Thus, a soil which consists mostly of coarse particles has a low ability to hold water, whereas finer soils hold more water.

From this illustration, we conclude that sandy soils have low water-holding capacity in comparison with clayey soils.

Structure - The arrangement of soil particles will determine to some degree the water storage capacity of a soil with reference to its surface area. A loosely arranged soil with a higher percentage of pore space will absorb water more readily; however, a fine-textured soil can store greater amounts of available water. Loamy soils often store larger amounts of water than clay soils with superior moisture storage capacity, simply because loamy soils permit more water to enter.

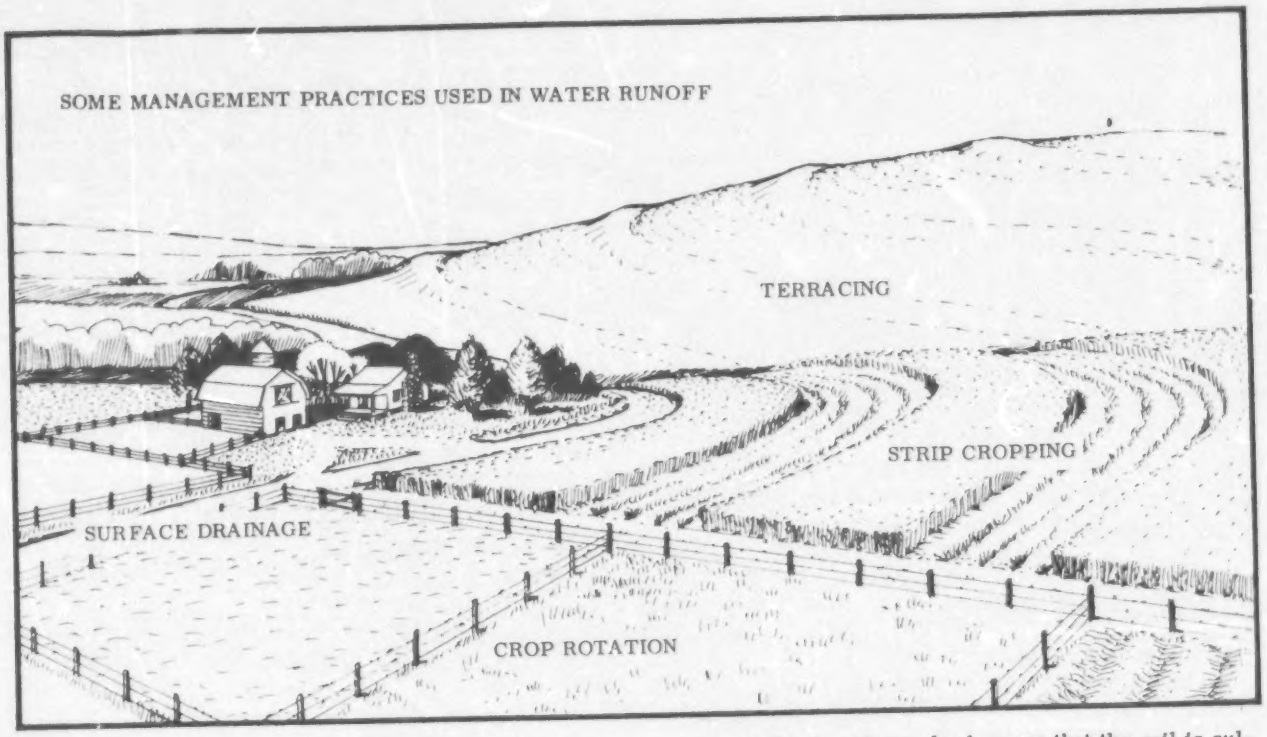
Organic matter - Organic matter has a tremendous influence on the water-holding capacity of a soil because it will hold water equivalent to an amount several times its weight. Organic matter influences water-holding capacity indirectly by increasing the pore space in fine-textured soils and by helping to fill in between large pores to increase the number of capillaries in coarse-textured soils.

II. RECOMMENDED PRACTICES FOR THE CONSERVATION OF SOIL WATER

After gaining some insight into the basic problems which the farmer or rancher must consider in the conservation of soil water, let's consider some practices which might be used to increase the availability and efficiency of soil water for plant growth.

A. Remove Excess Water

An over supply of water is as bad as a shortage of water. The excess water on the soil cuts down the supply of oxygen needed by plants. An over supply of water in arid regions may cause a build



up of salts on the top region of the soil. In irrigation regions salt may also build up on the surface of the soil.

B. Prepare Soil for Proper Infiltration

Infiltration means that the soil is capable of absorbing moisture.

Proper plowing and timing of plowing may help rearrange the structure of soil that is incapable of infiltrating proper amounts of water.

Crop residues on top of the soil may help the soil infiltrate water. Green manure and cover crops help add organic matter which increases the soil infiltration capacity.

C. Controlling Runoff of Water

The control of the runoff water will also decrease soil erosion problems, as well as help conserve soil moisture.

These and other improved farming practices when properly applied will help in conserving and controlling surface water runoff.

D. Weed Control on Crop Land

Weeds absorb water just the same as crops. In fact, weeds require more moisture to produce a pound of dry material than do crop plants.

E. Fallowing Crop Land

Fallowing of crop land means that the soil is cultivated but is not used for the production of any crop for a season.

The cultivation of the soil destroys many of the weeds and assists the soil in building up a supply of moisture.

It may also be noted that moisture content may be built up due to the lack of a crop being planted.

F. Crop rotation may be helpful in conserving soil moisture. Crops that require less water may be followed by additional crops with small losses of soil moisture.

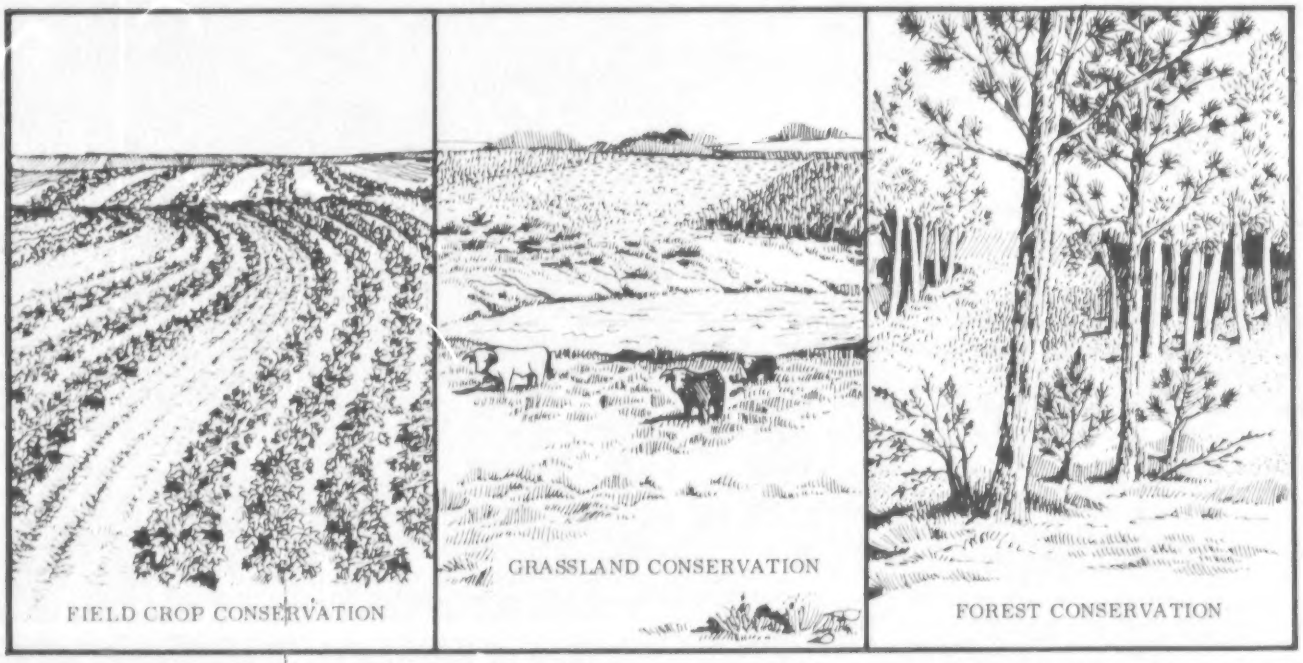
G. Adequate fertility is essential for efficient use of soil moisture.

Proper distribution of adequate amounts of all essential nutrients in the soil permits plants to make more effective use of limited moisture supplies in surface soil and also to extend their roots into subsoils for stored moisture.

The lack of necessary plant nutrients lowers the efficiency of water use by plants.

H. Storage tanks are also methods of conserving and controlling soil moisture.

Tanks may be used to supply moisture to the soil during drought periods. If this method (tank storage) of soil water conservation is used, a farmer would be wise to contact his soil conservation service office for expert advice.



III. APPLICATION OF WATER CONSERVATION PRACTICES

The rate of growth of plants is directly related to the available moisture in the soil. The ideal soil for plant growth from the standpoint of water supply is one that takes in the water that falls, allows the excess to drain away, and holds enough for plant use between periods of rainfall.

The following is a brief discussion of some conservation measures which may be used depending on the land use.

A. Field Crops and Water Conservation

In annual cropping an effort should be made to provide a good plant cover during the parts of the season that major crops are not grown. A good ground cover increases water intake.

Crop residues and mulches of hay or straw have proved to be a good substitute for plant cover in cultivated fields.

Some farmers protect their soils by leaving standing stubble in the fall and during fallow periods.

Control of weeds and nonbeneficial vegetation helps to conserve soil water losses from transpiration.

Infiltration rates of water have been found to be improved under a rotational cropping system.

The use of selected mechanical practices will help reduce water runoff and increase water intake.

B. Grassland and Water Conservation

Desirable grass stands and production of forage can be improved by controlling undesirable weeds, brush, and trees which use valuable soil moisture.

Grasses protect the soil from erosion and hold more runoff water, thus allowing more of it to enter the soil.

Grass plants and roots help to maintain the humus and organic matter content in the soil.

Grasses become dormant earlier in the fall; therefore, more water is stored in the soil for early spring growth.

C. Forests and Water Conservation

Properly managed forest stands reduce water runoff, and thereby help control water runoff and reduce soil erosion.

Selective harvesting of the trees will allow rainfall to reach the soil, and also will reduce the water transpiration loss from undesirable trees.

Forest stands reduce soil and soil water evaporation losses from windstorms by providing a protective cover for the soil.

GLOSSARY OF TERMS

1. Infiltration - The downward entry of water into a soil. Infiltration rate denotes how rapidly a soil will absorb water.

2. Degree of Aggregation - Soil aggregation is the binding together (cohering of groups of soil particles into clusters or masses such as clod, crumb, or block). The degree of aggregation in soils refers to the extent of water-stable aggregates which will not disintegrate easily and are of special importance to soil structure.

3. Adhesion - Molecular attraction which holds the surfaces of two substances in contact, such as water and soil particles.

4. Cohesion - The force that attracts or holds molecules of water (liquids or solids) together, owing to the attraction between like molecules.

5. Fallow - Allowing cropland to lie idle for the greater part of a growing season in order to restore productivity through the accumulation of water, nutrients, or both.

SUGGESTED STUDENT ACTIVITIES

1. What are the three basic problems relating to soil water which the landowner must consider in the management or conservation of soil water?
   a.
   b.
   c.

2. List the major factors that affect intake of water by soil.
   a.
   b.
   c.
   d.
   e.

3. What factors mainly control soil water movement in the soil?
   a.
   b.
   c.

4. _____ (Adhesion, Cohesion) is the force that attracts molecules of water to molecules of soil; and _____ (adhesion, cohesion) is the force that attracts molecules of water to one another.

5. The major factors affecting water storage capacity are _____, _____, and _____.

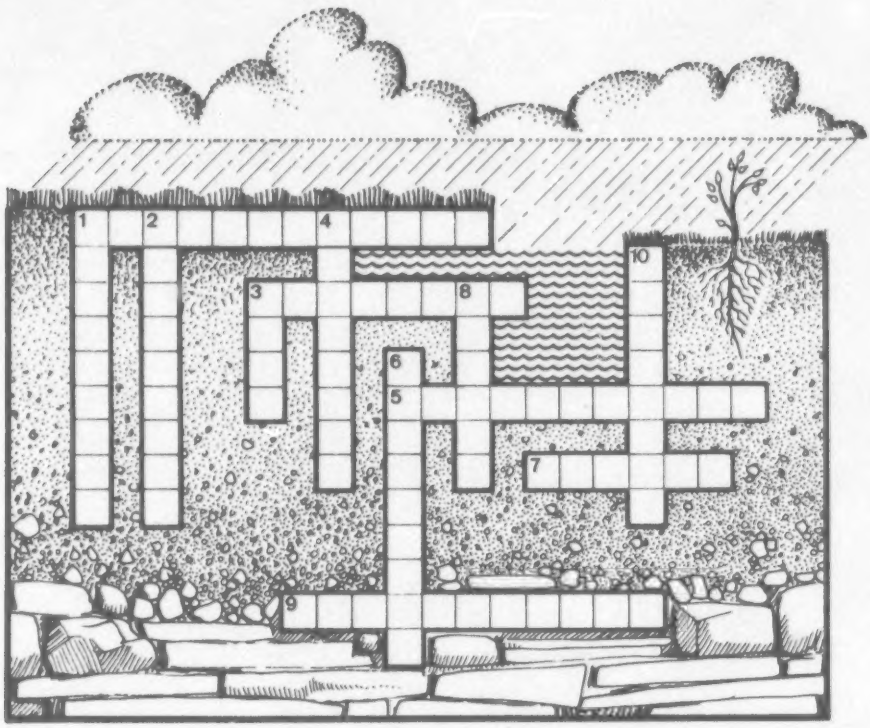
6. What are some practices that landowners might use to increase the availability of soil water for plant growth?
   a.
   b.
   c.
   d.
   e.
   f.
   g.
   h.

7. What are some cropland conservation practices that may be used to conserve soil water and reduce water runoff?
   a.
   b.
   c.
   d.
   e.

8. What are some pasture or rangeland conservation practices that may be used to improve soil water use?
   a.
   b.
   c.
   d.

9. What are some forest conservation practices that would help to reduce water runoff and to improve soil water efficiency?
   a.
   b.
   c.

10. Crossword Puzzle:



Across:

1. Tends to be higher in warm months than in cold months
3. Forces that attract molecules of water to one another
5. Cohering of groups of soil particles into clusters
7. _____ soils have less ability to hold water than fine soils.
9. _____ water has no movement and is not available for plant use.

Down:

1. A good ground cover (decreases, increases) water intake.
2. _____ of crop land means that the soil is cultivated but is not used for the production of any crop for a season.
3. _____ soils have a lower rate of water intake.
4. Attracts molecules of water to molecules of soil
6. _____ water may move in any direction in response to capillary tension.
8. Excess water on the soil cuts down the supply of _____ needed by plants.
10. Rate of plant growth is directly related to available _____ in the soil.

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